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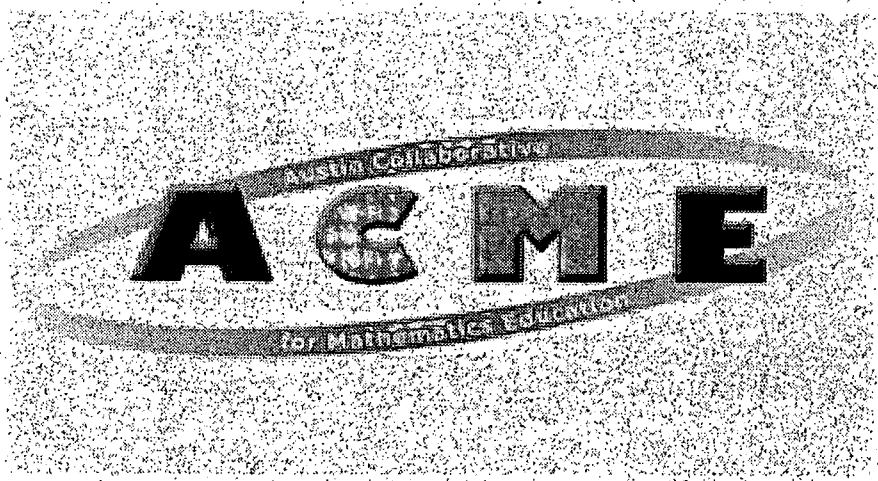
ABSTRACT

The Austin Collaborative for Mathematics Education (ACME) of the Austin Independent School District (AISD), Texas, is a systemwide initiative to support the implementation of the curriculum and appropriate use of resources, thus improving instruction in all K-8 mathematics classrooms in the district. The initiative, funded by the National Science Foundation with AISD supplements, provides long-term, high-quality professional development to build the capacity of all AISD mathematics teachers. The professional development focuses on the standards for mathematics education set by the state and the National Council of Teachers of Mathematics. A case study was conducted to examine in-depth factors that contribute to districtwide implementation of the AISD curriculum on individual campuses through skills and knowledge that teachers gain in ACME professional development. Evaluators gathered information through multiple site visits to nine AISD campuses with interviews with principals and teachers and surveys completed by teachers. The case study showed that mathematics lessons of teachers at all the schools manifested a range in standards-based mathematics curriculum and instruction. Differences in implementation levels emerged by teacher, and not by school. In general, the study did not reveal differences between schools with whole-school and grade-by-grade implementation, although schools with whole-school implementation did receive more support from the AISD. Teachers who implemented the program most effectively believed in the philosophy of standards-based mathematics education and were enthusiastic about the curriculum. Teachers who reported that they like the curriculum resources, were more likely to use them. Recommendations are made to improve the professional education offered under ACME. Appendixes contain principal and teacher interviews, the campus questionnaire, and a diagram of teacher collaboration at one school. (Contains 12 references.) (SLD)

AUSTIN COLLABORATIVE FOR MATHEMATICS EDUCATION

Case Study, 1998-1999



Austin Independent School District
Office of Program Evaluation

September 1999

Austin Collaborative for Mathematics Education, Case Study, 1998-99
Austin Independent School District

Executive Summary

The *Austin Collaborative for Mathematics Education* (ACME) is a systemwide initiative to support the implementation of the curriculum and appropriate use of resources, thus improving instruction in all K-8 mathematics classrooms in the district. The initiative, funded by the National Science Foundation (NSF) in August of 1997 and district supplements, provides long-term, high quality professional development to build the capacity of all AISD mathematics teachers. The professional development focuses on the standards for mathematics education set by the state in the Texas Essential Knowledge and Skills (TEKS) and by the National Council of Teachers of Mathematics (NCTM). These standards include broadening the topics taught at all grade levels, developing children's mathematical thinking, and deepening children's conceptual understanding through concrete experiences (Russell, 1998). The standards contrast with traditional mathematics education characterized by rote memorization and practice of computation. ACME professional development supports teachers in the implementation of the AISD curriculum using the district-approved curriculum resources of *Investigations in Number, Data, and Space* and *Connected Mathematics (CMP).*

The purpose of this case study is to examine in-depth key factors that contribute to districtwide implementation of the AISD curriculum on individual campuses through skills and knowledge that teachers gain in ACME professional development. In particular, the study evaluates the following factors: (a) school culture, or staffs' shared values and beliefs, as it relates to teachers' implementation of standards-based mathematics; (b) differences between grade-by-grade and whole school implementation; (c) the principals' role in supporting teachers' implementation of standards-based curriculum resources and instruction; and (d) the formal and informal ways that teachers collaborate to improve their skills and knowledge in standards-based mathematics education.

Evaluators gathered information about implementation through multiple site visits to nine AISD campuses, which included schools with grade-by-grade and whole school implementation. Most schools were selected because they were thought to be further along the continuum of implementation than others and some were selected because they were thought to be struggling to implement. Most were elementary schools that received Title 1 funds. The information was derived from interviews with principals and teachers, observations of mathematics lessons, surveys of teachers' attitudes and behaviors, and participation in team and committee meetings and family math nights.

Implementation of Standards-Based Mathematics Education

The ACME project is unique in scope because its goal is to help *all* elementary and middle school mathematics teachers in the district implement standards-based teaching and learning in mathematics. To examine the degree to which all targeted teachers were implementing standards-based mathematics, evaluators rated mathematics lessons from low to high or no implementation at all. Teachers' and principals' reports also provided information. The examination of implementation revealed the following results:

- The mathematics lessons of teachers at all nine schools manifested a range in standards-based mathematics curriculum and instruction, regardless of whether the schools were far along or struggling to implement. Differences in implementation levels emerged by individual teachers, not by schools.
- In general, the study did not reveal differences between schools with whole school and grade-by-grade implementation; teachers' skills were varied regardless of implementation design. However, campuses with whole school implementation received on-site support from ACME staff (e.g., modeling and discussing lessons) and appeared to have stronger mechanisms for supporting reluctant or hesitant teachers in implementing than did schools with grade-by-grade implementation.
- The characteristics of teachers who implemented effectively included: (a) beliefs in the philosophy of standards-based mathematics education; (b) excitement about the curriculum, willingness to learn, or strong skills in teaching mathematics; (c) confidence in the academic capacities of children; (d) classroom management that supported children's active engagement; and (e) efforts to learn how to implement the curriculum resources, despite fears or hesitancy.
- The more teachers reported that they liked using *Investigations* and *CMP* and the easier they found using the curriculum resources, the greater the number of lessons per week they reported teaching from the resources. There was a tendency for teachers new to the profession to be more willing to use *Investigations* and *CMP* than those with many years of experience.
- Alternative curriculum resources to *Investigations* and *CMP* included conventional textbooks, standards-based supplemental materials, and test format practice.
- Two factors negatively influenced whether teachers' implemented standards-based curriculum resources and instruction: On all campuses, some teachers expressed concerns about students' not passing the Texas

Assessment of Academic Skills (TAAS) and, on a few campuses, compounded crises on campus detracted from implementation.

Recommendations for improving the implementation of standards-based mathematics include the following:

- Continue to provide varieties of professional development that address the range of skills, knowledge, and interest levels teachers have in standards-based curriculum and instruction and include some information about TAAS successes and alignments.
- Continue to educate principals about strong support for the project to address the concerns of hesitant or reluctant teachers (see "The Role of Principals in Implementation").
- Continue to encourage teachers to try out standards-based mathematics materials and supplements because their feelings about them are related to use.
- Provide every campus with a library set of all curriculum resources so that teachers can access resources of lower grade levels to simplify lessons.

The Role of Principals in Implementation

Principals play an important role in the adoption of innovations like standards-based mathematics curriculum as leaders at the campus level. Strong support lies in the technical and ideological leadership they provide teachers. Interviews with principals and teachers on the nine campuses revealed the following information about how administrators were supporting the ACME project and the implementation of standards-based mathematics:

- Basic principal support for implementation included supplying kits to every teacher, special copying budgets for student sheets, and time for professional development. (Note that in the 1999-2000 school year, the board of trustees has funded kits for every teacher and copies of student sheets.) This level of support focused on the management of implementation, which, according to the Concerns-Based Adoption Model (CBAM, Hord et al., 1989), occurs early on in an innovation before concerns about its impact on children, teacher collaboration, and improvements the project itself.
- Strong principal support for implementation included:
  a. principal commitment to the ACME project, communication of the expectation that all teachers will implement the curriculum, and monitoring teachers' standards-based mathematics instruction;
  b. gathering information about standards-based mathematics education and selling it to parents, teachers, and the community;
  c. having a systemic vision of implementation and the need for district support of reforms; and
  d. providing time for teacher collaboration and peer coaching outside of weekly team meetings, and organizing and promoting strong teacher leadership, which occurred more often at schools with whole school than grade-by-grade implementation.

  Despite strong principal support, all faculty included teachers reluctant or resistant to implement standards-based curriculum (see "Implementation of Standards-Based Mathematics Education").
- A few assistant principals who had knowledge and expertise in standards-based mathematics education bolstered principal support for implementation on campus.
- Principal support that detracted from implementation included:
  a. campus goals that conflicted with the goals of ACME or were not broad enough to include standards-based mathematics curriculum and instruction;
  b. unclear understanding of how principals could support teachers in implementation, although thoughts about principals' roles developed over the course of the study;
  c. mixed messages about implementation (e.g., advocating for alternative curricula or no curriculum in particular), linked to a campus identity of separateness from the district; and
  d. support for the implementation of a few teachers on campus but not for all.

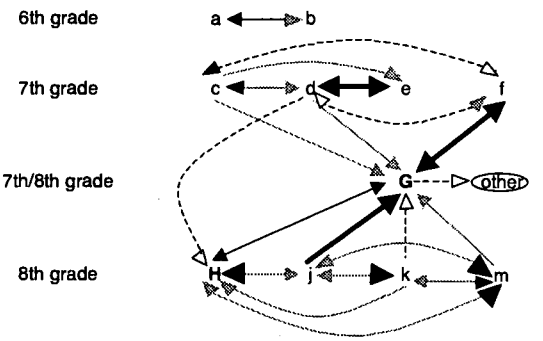
Recommendations for improving principal support for implementation:

- Continue to educate principals about the components of strong support for the implementation of standards-based mathematics education, and encourage them beyond basic support as managers of implementation.
- Educate central office administrators, board of trustees, and the community about the ACME project to foster clear messages districtwide and support for the implementation of standards-based mathematics.
- Address principal support that detracts from implementation and other AISD programs as a district initiative campus

Teacher Collaboration

Teacher collaboration allows educators to explore and learn innovative curriculum and instruction through the support of colleagues. Strong principal support for implementation occurred when administrators orchestrated teacher collaboration and leadership. Figure 1 illustrates an example of intensive teacher collaboration among 7th and 8th grade teachers. Letters represent individual teachers, bold capital letters (i.e., G and H) are teacher leaders, "other" is a colleague off campus, and arrows represent the frequency of collaboration (ranging from ---> less than once a week to → daily; see key on p. 28 of report). Observations of teacher collaboration at sites included the following:

Figure 1. Teacher collaboration at School A



- Although principals and teachers cited team meetings and shared planning times as opportunities for teachers to share materials and ideas about mathematics education, discussion of content and pedagogy at these times was rare.
- Teachers found "meaningful minutes" to share their experiences trying out the ACME resources. Sometimes the messages promoted implementation with good news; occasionally the information was negative or neutral.
- Only a few teachers collaborated deeply on standards-based mathematics education in pairs that were self-organized or mentoring relationships between experts and novices.
- Although several teachers on most campuses identified an expert in standards-based mathematics education, typically few teachers collaborated with that person to hone their skills and knowledge. Common reasons for not collaborating were structural, such as teaching different grade levels, having conflicting schedules, being too busy, and not working near one another.

Recommendations for improving teacher collaboration:

- Establish monthy or bi-monthly opportunities for teachers to collaborate on the content and pedagogy of standards-based mathematics education in their first two years of implementation. To ensure meaningful collaboration, require teachers to set goals for deep exploration of materials and to report back to faculty their discoveries made. Include book studies and analysis of student work and thinking.
- Identify teachers who are experts on campus in standards-based mathematics; organize mentoring and peer coaching relationships between expert and novice teachers; and provide experts with release time to visit other classrooms to observe or demonstrate lessons.
- To provide release time, for example, pay for substitutes for half-days, pay for extra planning times, make use of student teachers, or other methods. Funding sources could include NSF, Title, or Excel funds among others.

Teachers' Attitudes Toward ACME Professional Development

ACME professional development is a tool that supports the districtwide implementation of standards-based mathematics education. Teachers reported the following attitudes toward professional development:

- The most common benefit of ACME professional development was sharing their experiences with colleagues, which included innovations, extensions, and struggles. Previewing lessons, reviewing student work, discussing assessment, and having planning time also were appreciated.
- Information about the links between TAAS and the ACME curriculum resources in professional development allayed the fears of some teachers, but other teachers who had embraced the curriculum or were not interested in the details did not need the information.
- Teachers' attitudes toward ACME professional development were related to the positivity or negativity of their school cultures.

Recommendations for ACME professional development:

- Continue to provide high quality professional development in standards-based mathematics education that incorporates collaboration and the variety of interests and needs that teachers express.

Teachers' and Principals' Perceptions of Parents' Responses to Standards-Based Mathematics Education

Teachers and principals reported the following about parents' responses to standards-based mathematics:

- Teachers generally reported that parental involvement on their campuses was low.
- Teachers observed that parents struggled with standards-based mathematics, which demanded approaches to problem-solving that were unfamiliar and did not rely on traditional methods such as drill and computation practice; standards-based mathematics education confused and "took power away from parents."

- Teachers' attitudes toward the curriculum and their reports of parents' responses to standards-based mathematics appeared linked; teachers with positive attitudes seemed to report support from parents whereas teachers uncomfortable with the curriculum seemed to report negative parental attitudes.

Recommendations for garnering parental support for standards-based mathematics education:

- Educate parents about standards-based mathematics and improve parental involvement at the campus level; for example, send home classroom and/or campus newsletters with tips for implementation at each grade level, provide parents curriculum guides or primers on children's mathematics classroom activities, and expand family math nights to all campuses (e.g., the Dana Center's kit for standards-based parent education events).
- Enlist support for standards-based mathematics education from Campus Advisory Councils (CAC), parent leaders, and Parent Teacher Associations (PTA).

Teachers' and Principals' Views of Children and Standards-Based Mathematics Education

Relationships with children and improvements in their learning are some of the rewards of teaching. Teachers and principals reported the following changes in children's classroom experiences with mathematics:

- More children felt successful in and enjoyed mathematics than before. They also acquired a deep understanding of the mathematics content.
- Some teachers perceived drawbacks to standards-based mathematics education as they observed children struggling to communicate and write about mathematics.
- At a few sites, school culture reflected low expectations for students' capacities to achieve academically and a hopelessness about implementing standards-based mathematics curriculum.

Recommendations for improving views of children and standards-based mathematics education:

- Provide opportunities for teachers to observe students in classrooms of others skilled in standards-based mathematics instruction where children are excited about learning mathematics.
- In ACME professional development and at the campus level, encourage teachers to share their experiences with children's success in standards-based mathematics education.
- Continue to provide experiences in professional development that promote teachers' confidence in helping children to communicate and write about mathematics.
- Develop a districtwide strategy to increase expectations for all students' mathematics performance.

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We greatly appreciate the time and willingness to share information of the teachers and administrators from the nine AISD schools who participated in the case study. The information and policy recommendations gained from this evaluation will help the staff of the ACME project improve the implementation of standards-based mathematics on these sites and across the district.

OVERVIEW OF THE PROJECT

The *Austin Collaborative for Mathematics Education* (ACME) is a systemwide initiative to improve instruction and support the implementation of AISD curriculum in all K-8 mathematics classrooms in the district. In August of 1997, the National Science Foundation (NSF) funded the ACME project, which is a partnership of the Austin Independent School District (AISD), the Charles A. Dana Center, and the University of Texas at Austin. The initiative provides long-term, high quality professional development to build the capacity of all AISD mathematics teachers.

ACME professional development focuses on the standards for mathematics education set by the state in the Texas Essential Knowledge and Skills (TEKS) and by the National Council of Teachers of Mathematics (NCTM, 1989, 1991, & 1995). These standards include:

- Broadening the topics taught at all grade levels to include work in geometry, data, probability, patterns, and other topics that have received little attention in the past;
- Developing children's mathematical thinking, reasoning, and problem-solving skills;
- Deepening children's understanding of mathematical concepts through hands-on experiences, real-world problems, and communication;
- Including children (e.g., special education, bilingual, and culturally diverse) who have been excluded from the mathematics curriculum in the past; and
- Actively involving teachers in children's learning by requiring a deep understanding of mathematical concepts and of how children develop mathematical thinking (Russell, 1998).

The standards contrast with traditional mathematics instruction and curriculum that emphasize mathematical algorithms, rote memorization, and mastery of computation, in which children are passive recipients of teachers' knowledge (Cohen & Ball, 1990). The district-approved resources to promote standards-based mathematics education are *Investigations in Number, Data, and Space* and *Connected Mathematics* (CMP).

The ACME project is unique in its scope because it provides *all* elementary and middle school mathematics teachers in a large urban district with long term, high quality professional development in the standards for teaching and learning mathematics. Inherent in a reform initiative of this scope is the assumption that every K-8 mathematics teacher in the district will integrate standards-based mathematics into his or her current teaching practices. These changes are expected regardless of teachers' current teaching style, job commitment, the variety of other initiatives in which they participate, and so on. Many initiatives in mathematics education begin at the grassroots level or involve a pool of volunteers. When implementation is voluntary, interested teachers may get involved early on, whereas teachers who feel lukewarm or negatively need not participate until they themselves feel ready, if ever. In contrast, when implementation is districtwide, as is the case in AISD, all or most teachers are expected to participate in the project from its inception, regardless of their interest level or willingness. One purpose of this evaluation

is to describe key factors that contribute to districtwide implementation of standards-based mathematics curriculum and instruction through ACME.

The ACME initiative is part of the districtwide plan to improve mathematics education. Changes in teaching practices, however, emerge in classrooms with teachers, children, administrators, and parents. School culture is one key factor that influences the work of teachers in classrooms. *School culture* is a system of values and beliefs, both explicit and implicit, that campus members share (Erickson, 1991). Campus beliefs related to changing mathematics curriculum and instruction may include, for example, openness to innovative teaching practices, acceptance of student activity in classrooms, and the expectation that all students on a campus can achieve in mathematics. Campus beliefs can emanate from teachers, reflect messages from campus leaders, or enter from outside sources such as district administrators or the community. This evaluation focuses on school culture and how it relates to implementation of standards-based mathematics on individual campuses.

Research establishes the key role of campus administrators in school cultures (Peterson & Martin, 1990). In districtwide improvement plans, which include initiatives like ACME, principals are influential in supporting teachers in the adoption of reforms as technical and symbolic leaders at the campus level. Principals' knowledge and beliefs in national standards for mathematics curriculum and instruction influence the messages and expectations they communicate to teachers on their campuses; the clarity of messages is associated with strong leadership (Peterson & Martin, 1990). What principals know about teaching strategies on their campuses influences how they guide teachers through the implementation of standards-based mathematics. Principals can also influence implementation by formally organizing teachers on campuses (e.g., curriculum committees or teams) and by planning innovations that provide teachers time to reflect on their practice. In light of the influential role of campus administrators, this evaluation examines the extent and means by which principals in the district support the adoption of the standards-based mathematics curriculum and instruction.

In addition to campus administrators, collegiality and collaboration can help teachers overcome the challenges of learning and adopting new curriculum and instruction (Lieberman, Saxl, & Miles, 1988). The isolation of teachers in classrooms may hinder opportunities for adults to work together and establish a professional learning community. Time during the work day to share and learn from others' experiences to make sense of curriculum resources can influence the progress teachers make. Moreover, some teachers may develop skills and knowledge in standards-based teaching practices more swiftly than others, for example, through professional development, formal education, or self-motivation. Researchers have long pointed out the "egalitarian ethic" that many teachers share, which is the belief that teachers are similar regardless of experience, age, grade level, or subjects taught (Lortie, 1975). While the egalitarian ethic may result in teachers and principals treating each other as equals, it may deprive some of the opportunity to improve by learning from peers with greater competencies. The final focus of this evaluation is formal and informal teacher collaboration to improve skills and knowledge in standards-based mathematics education outside ACME professional development with special attention to teacher leadership that may emerge.

EVALUATION DESIGN

The design of this component of the evaluation of the ACME project is an in-depth case study. This design allows observers to gather a wide variety of data from specific contexts, in this case, schools that are implementing the ACME curriculum resources. Because the design focuses on individual campuses, it reveals the range of factors that influence the development of standards-based mathematics in the campus environment and allows observers to draw conclusions about the relationships among these factors. In addition, gathering observations at several different sites allows for comparisons of similarities and differences across sites.

Site Selection

This case study involves an in-depth look at nine schools in the district that are participating in ACME professional development. In May of 1998, a team of evaluators and program staff met to determine topics to examine, plan the case study, and suggest sites to visit. The team decided to select schools that were beginning to implement inquiry-based mathematics curriculum and instruction and to include variations on a continuum of implementation. Most of the schools were thought to be further along in implementing standards-based mathematics curriculum resources than others in the district and a few were selected because they were thought to be struggling with implementation. To preserve confidentiality, this case study does not reveal the identities of the schools, principals, or teachers who participated.

The team decided to sample the two different models of implementation that are part of the ACME project design: *grade-by-grade* and *whole school* implementation. The general implementation model for ACME is grade-by-grade in which one grade per school begins professional development at a time. In the 1997-98 school year, implementation began with 5th and 6th grade teachers; in the 1998-99 school year, it added 4th and 7th grade teachers; and in the following years, it will include teachers of the remaining K-8 grades. In whole school implementation, teachers at every grade level in a school begin professional development simultaneously. The district has eight elementary schools with whole school implementation, called "pilot" schools. These elementary schools applied to participate, and the AISD Mathematics Department selected them on the basis of commitment and investment in inquiry-based mathematics curriculum and instruction.

Three middle schools in the district are called "pilots," but their implementation and support differs from that of the pilot elementary schools. The pilot middle schools participate in professional development and special programs through an NSF-funded Statewide Systemic Initiative (SSI) directed by the Charles A. Dana Center. Pilot middle schools participated in grade-by-grade implementation, but had involved teachers of all grade levels in professional development before this case study began. These schools were selected on the basis of concerns about low student performance, a history of faculty stability, and a desire to improve student mathematics achievement. For the purposes of this evaluation, these middle schools are considered "pilot" schools because they began implementing standards-based mathematics curriculum resources and instruction before others and receive extra support from the AISD Mathematics Department. Four schools

in the case study are pilots and have whole school implementation; five schools have grade-by-grade implementation.

Another criterion for selecting campuses to participate in the case study was to examine schools where students' backgrounds are economically as well as racially and ethnically diverse. Therefore, all but two of the schools selected received Title 1 funding in the 1998-99 school year. In addition, a middle school was selected to compare schools in which educators teach only mathematics with those who teach all or most subjects, as is common in elementary schools.

Site Visits

Two evaluators visited the nine selected schools for a half day at least once during the fall semester and returned to eight of the nine schools at least once during the spring semester. One school was not included in the second visit because its implementation resembled that of another school in the sample. Because one of the purposes of the second visit was to fill in gaps and follow up on information gathered at the first visit, each visit was scheduled at a time that was different from the first visit (i.e., if the fall visit took place in the morning, then the spring visit took place in the afternoon). The evaluators made additional visits to attend meetings and to interview participants who were otherwise unavailable.

At the site visits, the information gathered was comprehensive and varied. Together the evaluators interviewed the principals at each school, and assistant principals wherever possible, for 30 minutes regarding the progress of implementation on their campuses, their role in implementation, teacher collaboration, and the alignment of the ACME project with campus goals (see Appendix A for the Principal Interview). Due to scheduling difficulties, a few interviews with campus administrators occurred over the phone. At the second visit, the evaluators also asked short follow-up questions. For about 15 minutes during planning time, one or both evaluators interviewed teachers individually about their experiences with adopting inquiry-based mathematics curriculum and instruction, ACME professional development, students' experiences in mathematics lessons, parents' responses to the project, teacher collaboration, and administrative support for implementation (see Appendix B for the Teacher Interview).

On the first visit, teachers were interviewed on the basis of availability. At schools with grade-by-grade implementation, most of the teachers that the evaluators interviewed taught grade levels currently targeted by ACME. Some teachers interviewed did not teach targeted grade levels, but principals or colleagues identified them as implementing. On the second visit, evaluators interviewed teachers at targeted grade levels that were skipped on the first visit and teachers whom principals and colleagues identified as leaders in implementing inquiry-based mathematics curriculum and instruction. The number of teacher interviews at each campus ranged from 4 to 12 interviews with an average of 8 interviews per school.

In addition, the evaluators informally observed the mathematics lessons of teachers of grade levels targeted for implementation and lessons of a few teachers of grade levels not targeted but whom administrators identified as trying out the curriculum. To sample the degree of implementation, the 15 to 30 minutes observations focused on the engagement level of students, the culture of the classroom, the quality of

communication, and the instructional strategies. The number of observations at each campus ranged from 4 to 10 with an average of 7 observations per school.

Additional information about schoolwide implementation was gathered through observations of other school events. At nearly every campus, evaluators observed at least one grade level team meeting. Some schools held family math nights or curriculum meetings that evaluators attended. One school held a math cadre meeting and another held a curriculum specialist meeting, both with one representative per grade level. Another school held a grade level planning meeting that was focused on mathematics for half of the day. The evaluators' roles in these meetings was usually neutral observer but at times evolved into focus group facilitator.

At all of the eight schools revisited in the spring, a short questionnaire was delivered to the mail box of every teacher on campus. The questionnaire asked about previous teaching experience, participation in ACME professional development, teachers' feelings about using the ACME designated curriculum resources of *Investigations* and *CMP*, and teacher collaboration (see Appendix C for the *ACME* Questionnaire for Campuses). If a teacher did not return the first copy of the questionnaire within a few weeks, a second copy was forwarded to campus administrators who attached a memo or otherwise urged that the forms be completed. The overall return rate for the questionnaires was 85% and ranged from 77% to 100% on each campus. Despite this high return rate, many teachers who returned questionnaires did not respond to items that asked them to name colleagues, such as with whom they collaborate or which teachers they considered to be most knowledgeable and skilled at using *Investigations* and *CMP*. Teachers may have skipped this section because it involved identifying colleagues; at one school, teachers said that they felt that the questionnaire had implications about how they should do their jobs.

RESULTS AND DISCUSSION

Implementation of Standards-Based Mathematics Education

Implementation involves a plan, the tools to carry out the plan, and work to accomplish the plan. In the case of the ACME project, the goal of implementation is all K-8 mathematics teachers in the target grade levels will adopt the teaching practices of inquiry-based mathematics education. Professional development, curriculum resources, and district support are some of the tools in place to further that goal. Teachers, administrators, and other district personnel carry out the plan.

Comparison of levels of implementation across schools

To assess the degree of implementation on the nine campuses in this study, the evaluators observed mathematics lessons and rated the observations from low to high implementation or no implementation at all. For **low** implementation, the lesson involved a mathematics activity, which sometimes involved the ACME curriculum resources. Students were not deeply engaged with the teacher, other students, or mathematical concepts. Manipulatives may have been available, but students did not use them to model and discover solutions to complex problems. For **medium** implementation, the classroom had an investigative culture in which students explored mathematical concepts, but the instructional strategies and student involvement were limited. For **high** implementation, the teacher skillfully facilitated a standards-based lesson and supported students' deep exploration of mathematical concepts. In addition, the communication and involvement of most students in the lesson involved reasoning, explaining, and justifying solutions to complex mathematical problems. For **no** implementation at all, the lesson did not involve inquiry-based mathematics and centered on drilling basic facts and practicing computation or test formats.

The children in classrooms with high levels of implementation were actively engaged in lessons. They were explaining their ideas and correcting or challenging the ideas of other students. The discussions among students or between students and teachers were lively and focused on exploring mathematical concepts that connected to the problems at hand. The fact that a lesson involved ACME curriculum resources did not ensure high levels of implementation. Instead, when teachers carried out an *Investigations* lesson with little understanding of the mathematics behind it and failed to get students actively and deeply involved, the level of implementation was generally low. At low implementation levels, students did not appear to learn much mathematics.

Table 1 presents the results of the classroom observations. The frequencies indicate that all schools in the study manifested a range of implementation from low to high levels. This finding is intriguing given that some schools were selected because they were considered to be implementing well, whereas other schools were thought to be struggling to implement standards-based curriculum resources and instruction. However, regardless of the overall appearance of implementation, some teachers on all campuses excelled in standards-based curriculum and instruction, some were trying it out somewhat

effectively but were still developing skills, whereas others were at the beginning stages of learning these skills and not yet effective. Thus, in the ACME project's second year of implementation, teachers on all of these campuses presented a range of competencies in inquiry-based teaching and learning. At none of these nine schools was *every* teacher effectively implementing standards-based mathematics education. It could be that schools with strong principals were perceived as further along in implementation than other schools (see "The Role of Principals in Implementation").

Table 1. Frequencies of Levels of Implementation by School

Schools	Total	Levels of implementation: None	Low	Low/ Medium	Medium	Medium/ High	High
Pilot							
A	**9**	0	**4**	0	**1**	3	**1**
B	**5**	0	**1**	2	**1**	0	**1**
C	**7**	0	**2**	0	**3**	1	**1**
D	**8**	0	**3**	1	**2**	0	**2**
Grade-by-grade implementation							
E	**4**	0	**1**	0	**2**	0	**1**
F	**7**	0	**2**	1	**2**	1	**1**
G	**7**	3	**1**	0	**2**	0	**1**
H	**4**	0	**1**	1	**1**	1	**0**
I	**10**	1	**2**	1	**4**	1	**1**
Total	**61**	**4**	**17**	**6**	**18**	**7**	**9**

Source: Classroom observations

Grade-by-grade vs. whole school implementation

One evaluation question is whether pilot schools have higher levels of implementation than schools with the grade-by-grade model. Because pilot schools involve teachers at all grade levels in implementation simultaneously and were selected on the basis of commitment and investment in standards-based mathematics or the desire to improve student mathematics achievement, they may have a greater amount of energy and support for trying out standards-based mathematics education than other schools. In ACME's second year, pilot schools received site-based support from district mathematics specialists for about two days per month, which included modeling lessons, discussions with teachers about practice and student learning, and other forms of encouragement. Surprisingly, despite these conditions, the level of implementation at the pilot schools generally did not differ from that at schools with grade-by-grade implementation at this phase of the ACME project.

The only difference observed between pilot schools and those with grade-by-grade implementation was that two of the five schools with grade-by-grade implementation, but none of the pilot schools, had teachers who were rated as not implementing at all. Perhaps campus staff at pilot schools address resistance or reluctance to implement more effectively than staff at other schools. At one of the pilot schools, the principal confronted a campus resistor head on and discussed the mathematics achievement of the

teachers' students on the TAAS (Texas Assessment of Academic Skills) without standards-based instruction. At another pilot school, teachers identified as reluctant to adopt standards-based curriculum and instruction in the fall were observed being helped by skilled teachers in the spring and trying out the teaching practice. These assisted teachers expressed positive or mixed attitudes toward inquiry-based mathematics education. Thus, schools that volunteered to participate in whole school implementation appear to have developed mechanisms for addressing and supporting reluctant or hesitant teachers with implementing standards-based mathematics curriculum resources and instruction.

The two schools at which one or more observed teachers who were not implementing in targeted grade levels were unique in that district mathematics specialists had encouraged these schools to become pilots. At both of these schools, the principals stated that they intentionally did not apply to become a pilot. At one school, not all of the teachers voted in favor of becoming a pilot, and the principal decided not to apply without the support of the entire faculty. This school still moved ahead of the ACME grade-by-grade implementation schedule with untargeted grade levels trying out the curriculum resources. In addition, this campus appeared to have a small faction of teachers who were against implementation, but this opposition did not seem to hamper the efforts of other teachers to try out or excel in standards-based mathematics education. At the other campus, the principal decided that the school already had several innovations on its plate and did not want to overwhelm her staff further. Thus, at schools with grade-by-grade implementation, the insistence that *all* teachers in targeted grade levels implement the curriculum resources may be less strong than at pilot schools.

Although in the second year of the ACME project the classroom observations did not reveal differences between pilot and grade-by-grade schools in implementation, perhaps in future years differences will emerge. Pilot schools may have a head start and benefit from the critical mass of whole school implementation. These schools may have more teachers who have participated in professional development, more knowledge and experience, and more district support than schools with grade-by-grade implementation. Because the design of this case study is longitudinal, the evaluators will revisit this question as the project evolves.

Characteristics of effective implementation

In the ACME project's second year, evaluators did not observe high levels of implementation in individual schools, but rather in the lessons of individual teachers. Classroom observations and interviews with teachers with high levels of implementation of inquiry-based mathematics education presented the following characteristics:

- Belief in or acceptance of the philosophy of standards-based mathematics education (e.g., children learn best when they start with concrete models and move to abstract concepts, children are active participants in learning and teachers facilitate their development to higher levels of understanding, and communication is a means of improving conceptual understanding);
- Excitement about teaching mathematics, a willingness to learn more about mathematics, or strong skills in mathematics;

- Positive regard for children and confidence in their capacities to achieve academically;
- Smooth classroom management that allowed children to be actively engaged in learning—the more children were actively engaged in interesting activities, the less time the teacher seemed to spend disciplining individual children; and
- Efforts to learn how to implement standards-based mathematics curriculum resources and instruction despite fears or hesitancy.

Teachers who were observed demonstrating high levels of implementation arrived at effective instruction through a variety of routes. Some teachers had developed standards-based philosophy and teaching strategies before the ACME project began either through college education or other professional development. Some teachers showed individual motivation and were open to professional growth and new ideas about teaching. Still others received strong support for adopting standards-based curriculum resources and instruction from their grade level teammates, a teaching partner, or a campus administrator. (Other forms of support for implementation will be discussed in-depth in subsequent sections.) Often, more than one of these factors influenced teachers' implementation of standards-based mathematics education.

Teachers' behavior and attitudes toward implementation

The frequency with which teachers use the ACME curriculum resources may be associated with their attitudes toward the resources. The teacher questionnaire revealed significant relationships between teachers' attitudes and the frequency of use. The more teachers reported that they liked using the resources and the easier they found using them, the greater the number of *Investigations* and *CMP* lessons per week they reported teaching. These relationships held for teachers at grade levels targeted for implementation (i.e., all teachers at pilot schools and 4th through 7th grade teachers) and for teachers not yet targeted for professional development as well. The correlations were highly significant (r = .32 and r = .36, respectively, $p < .01$). However, because these statistics are correlations, one cannot draw conclusions about causality. It is just as probable that teachers' liking to use *Investigations* or *CMP* influences how many lessons they teach from these resources per week as it is that the number of *Investigations* and *CMP* lessons per week that educators teach influences how much they like using the resources and find them easy to use.

It is also interesting to note that some teachers mentioned that they had difficulty completing an entire lesson in one day, which may relate to how much they like using the curriculum resources and find it easy to use. For example, when a lesson that should last one day takes more than one, teachers may have more negative attitudes toward the curriculum resources. On the other hand, teachers who struggle less to get through the lessons of the ACME curriculum resources may have more positive attitudes.

Some principals and teachers voiced the theory that educators who are new to the profession are more willing to adopt standards-based mathematics than those who have many years of experience. One principal explained that experienced teachers who already have perceptions about the way mathematics should be taught are set in their ways of thinking, whereas new teachers are more willing to try out inquiry-based mathematics

education. This principal also observed that at her school the retirement of experienced teachers "set the tone for change." Another principal suggested that an experienced teacher who was unwilling to move from the classroom she had taught in for years to another room near a teacher skilled at standards-based mathematics instruction might not want to adopt new curriculum resources and teaching strategies. Teachers also support this theory. One teacher who openly expressed her dislike of the ACME project gave as one of her explanations, "I'm an old teacher" implying that she is set in her ways.

The questionnaire provides data to test this theory. Associations between teachers' reports of the number of years they have taught and how many lessons per week they taught using the ACME curriculum resources revealed a significant trend. The more years of experience a teacher reported having, the fewer lessons from *Investigations* and *CMP* she taught per week ($r = -.22$, $p < .05$). This trend held true only for teachers who were targeted for implementation (i.e., pilot school teachers and 4th through 7th grade teachers). Probably no association was found for all of the teachers at these schools who returned questionnaires because all teachers who are not targeted for implementation are unlikely to use the curriculum resources, regardless of their experience.

It is important to note that correlations range from 0 to positive or negative 1, with 0 indicating no relationships between variables and 1 or -1 indicating a perfect relationship. Because a correlation of -.22 is close to 0, the correlation is weak to moderate and there are probably exceptions to the trend. For example, one could encounter an experienced teacher who latches on to standards-based curriculum and instruction and implements the resources often as well as a teacher new to the profession who rarely implements.

Another theory about implementation that some administrators expressed is that adopting standards-based curriculum and instruction is easier for primary teachers than for those who work with older children. One principal stated, "Primary teachers...have a constructivist paradigm and they've always held to that hands-on learning." Others pointed out that primary teachers have been working with cooperative groups and centers for years so that adopting these teaching practices is not new. Although this theory is plausible, testing the effects on the implementation is not presently possible because few primary teachers have participated. This question can be addressed as the project begins to target primary teachers.

Teachers' beliefs about using standards-based curriculum resources

The last item of the teacher questionnaire asked teachers to provide "any comments, concerns, or experiences" that they wished to share about using *Investigations* or *CMP*. Among teachers who responded, more than half of these responses (164 out of 305) focused on attitudes and feelings about using the curriculum resources and materials. One-third of these comments (59 out of 164) were positive or neutral, but two-thirds (105 out of 164) were negative. In a large number of the positive comments (n=31), teachers stated that they enjoyed using it or thought the ACME project was strong. Some teachers (n=11) liked the use of manipulatives and hands-on experiences that help children build conceptual understanding, and two teachers thought the activities were good. Several teachers (n=5) found the lessons easy to follow.

Negative comments contrasted with the positive ones. Some teachers (n=13) thought that the books needed be more teacher friendly (i.e., organized differently). Some teachers found the books to be wordy (n=4), in need of more practice problems (n=3), or lacking explanations before jumping into concepts (n=5). Some teachers (n=14) stated that the curriculum resources needed supplemental materials or were incomplete. Some teachers (n=6) commented that assessment was difficult and ambiguous or that they did not always know if students understood the lessons. Some teachers requested more resources. Several (n=3) thought that every teacher should have his/her own manipulatives kit. Several bilingual teachers (n=5) reported that they needed student sheets in Spanish, and several (n=4) asserted that translating materials into Spanish was a problem or that the Spanish version of the resources were hard to follow. It is interesting to note that most of these comments were about materials, but only one group of positive comments made connections to the development of children's mathematical thinking.

Alternatives to standards-based curriculum resources

To explore the decisions teachers made about curriculum resources and instruction, the questionnaire asked what other resources educators used in mathematics lessons when they were not using *Investigations* or *CMP*. Table 2 presents the total number of unique resources teachers reported using and the percentages for each type of curriculum resource listed by school and overall. Across campuses, teachers listed 54 unique resources other than *Investigations* or *CMP*. In general, teachers at pilot schools listed fewer unique resources (ranging from 8 to 16) than did teachers at schools with grade-by-grade implementation (ranging from 16 to 24).

Table 2. Percentages of Other Curriculum Resources Used by School

	Schools								
	Pilot			Grade-by-grade implementation					
	A	C	D	E	F	G	H	I	All
	Percentage of total number of resources listed								
Type of resource									
Test format practice	40	7	10	14	16	18	31	14	17
Standards-based supplements	0	11	28	29	9	28	3	22	18
Other supplements	20	0	3	7	5	6	18	13	8
Fun activities & group work	0	14	15	10	0	6	8	8	9
Standards-based curriculum	0	0	0	0	9	1	2	6	4
Conventional textbooks	30	39	18	28	34	20	20	18	24
Teacher-made materials	10	0	13	9	2	7	10	7	7
Other	0	29	13	3	25	14	8	13	13

Source: Teacher questionnaires

The types of curriculum resources that teachers listed include: (a) **test format practice** (e.g., *Kamico* and *Step up to TAAS*); (b) **standards-based supplements** (e.g., Marilyn Burns' *Math Solutions*, *Math Their Way*, and *GEMS*); (c) **other supplements** (e.g., *Touch Points*, *Creative Problem Solver*, and basic skills practice); (d) **fun activities and group work** (e.g., math centers, games, and *Making Math Memorable*); (e)

standards-based curriculum (e.g., *Mathland*); (f) **conventional textbooks** (e.g., Scott Foresman's *Exploring Mathematics/Explorando Mathematicas* and *Math Today*); (g) **teacher-made materials**; and (h) unspecified **other** materials.

In general, the most commonly cited curriculum resource was conventional textbooks (24% for all schools). Some schools (D, E, G, and I), on the other hand, used standards-based supplemental materials more than others, and two schools (A and H) used test format practice more than others. The common use of conventional textbooks is not surprising because they were the district's adopted texts at the time; the ACME-designated resources of *Investigations* and *CMP* were not. The commonality of test format practice fits with the state context of accountability in education and the emphasis on the TAAS. However, the schools where over 30% of the alternative curriculum resources involved students' practicing test format may be sacrificing rich instructional materials and spending a disproportionate amount of time teaching to the test.

At two schools (E and H), at least 25% of the teachers who responded used four and five alternative curriculum resources, whereas the average across schools was two alternative resources and teachers at five of eight schools commonly used only one alternative resource. At these two schools, principals sent mixed messages about the implementation of standards-based mathematics by encouraging teachers to use multiple curricula (see "The Role of Principals in Implementation, Components of principal support that detract from implementation, Mixed messages about implementation"). The convergence of these findings demonstrates the role of principals in the curricula and instruction that teachers use. In addition, teachers at schools with grade-by-grade implementation more commonly used alternative curriculum resources than did teachers at pilot schools. This finding suggests that the curriculum at pilot schools may be more focused than at other schools. On the other hand, teachers at schools with grade-by-grade implementation may make more curriculum decisions independently or have more freedom to try out different materials than teachers at pilot schools

Factors that negatively influence implementation

Concerns about students' passing TAAS

Certain factors emerged that could negatively impact implementation of the ACME project. With TAAS, the state government holds teachers, principals, schools, and districts accountable for student academic achievement. Some teachers who were hesitant to try out standards-based teaching strategies cited concerns about students' performance on the TAAS. One teacher expressed her concerns:

> I'm worried. I don't think they [the students] are going to be ready. I know that it's [Investigations] so fun, they just think its all a game. When I give them TAAS practice, they **have not** made the connection.
> *Source: Teacher interview*

Another teacher who stated that she did not like this program (i.e., standards-based mathematics curriculum and instruction) said:

> We do TAAS every day. I do Kamiko... [which asks] where's the question, where's the key word. They're doing excellent in TAAS review.... We hit TAAS hard. I'm not secure in the curriculum and I don't think 'Investigations' is helping me. My kids didn't know how to do two-place multiplication and rounding off.
> *Source: Teacher interview*

In contrast, another teacher who expressed both positive and negative attitudes toward implementing the curriculum noted the school's yearly improvement in student mathematics scores on the TAAS as support for implementation. Thus, educators who are uncomfortable with inquiry-based curriculum and instruction and whose teaching practice is geared toward preparing students to pass the TAAS may not willingly try out and implement the curriculum resources.

The conclusion that some teachers draw from these concerns is that children need to go "back to the basics." They consider ACME curriculum resources to be too difficult for their students, and want to use materials that are simpler. Perhaps, if teachers had access to the ACME resources of grade levels lower than their own on their campuses, they could integrate lessons that break down the content to basic levels.

Like these teachers who feel pressure to ensure that their students pass TAAS, principals look for evidence that the implementation of standards-based mathematics positively impacts students' scores on the TAAS. One principal remarked that her school's TAAS mathematics scores did not go up in the first year of implementation. The implication is that her support for the ACME project is contingent on student performance on TAAS. Another principal whose school had a small proportion of students pass the mathematics segment of TAAS in a recent academic year said, "We are using a repertoire of ways to teach; we use what works for the individual child, we're not using a program." The implications of this statement is that this school is using whichever mathematics programs that the campus feels works with individual children and that implementing standards-based curriculum resources is secondary to meeting that goal. In contrast, one principal strongly supported implementation of standards-based mathematics and took responsibility away from teachers for students' TAAS scores (see "The Role of Principals in Implementation, Components of strong principal support for implementation, Commitment and expectations"). Thus, the state accountability system has the potential to draw the attention of educators and administrators away from implementing a project like ACME, especially if results in student mathematics achievement are not swift and self-evident.

Compounded crises on campuses

Another factor that appeared to negatively influence efforts to implement were the number of crises at an individual school. Low student performance on past achievement tests is one crisis that constrained the freedom of teachers and principals to learn and implement an innovative method of instruction like standards-based mathematics. One principal pointed out that mobility and large numbers of migrant and Limited English

Proficiency (LEP) students also influenced the focus of teaching on her campus. In addition, turn over in teachers and administrators may drain campuses of resources, such as experiences in professional development in standards-based mathematics, may refocus campus energy on building work relationships, and move attention away from adopting innovative curriculum and instruction. Evaluators also observed structural stressors that infringed on the smoothness of teaching and learning at some schools. For example, new buildings under construction brought noise and distraction as well as interrupted pedestrian traffic on campuses. An old school building in disrepair seemed depressing and negatively influence morale. In some locations, portables separated teachers from the flow of information and activities in the main buildings. Thus, on the basis of interviews and evaluators' observations, it appears that some campuses experienced a large number of stressors and were in crisis. Contending with compounded crises may negatively influence the *psychic energy*, or interest and enthusiasm that teachers and principals put forth to implement standards-based mathematics instruction.

Summary of Implementation of Standards-Based Mathematics Education

In sum, in the second year of the ACME project, the quality and quantity of implementation did not appear to differ across sites. All schools in the case study presented a range of implementation, whether involved in whole school or grade-by-grade implementation, though future differences may emerge. Teachers' attitudes toward the ACME curriculum resources were more positive the more lessons they implemented each week. Concerns about students' performance on standardized tests and compounded crises on campuses emerged as factors that detracted from implementation of standards-based mathematics education.

The Role of Principals in Implementation

Information about the role principals play in implementation derives from the perspectives of campus administrators who lead and manage campuses as well as from teachers who receive direction, support, and guidance. At most schools, campus administrators provided teachers with basic support for implementation. Yet, some administrators went beyond the basics and supported implementation of standards-based mathematics education in ways that promoted the professional growth of teachers. This support was particularly powerful in addressing hesitance or reluctance of teachers to implement, in building collaborative relationships between teachers who were skilled in standards-based teaching practices and those who were not, and in communicating solid support that sustains teachers who take off with the curriculum. Some campus leadership, on the other hand, communicated mixed messages that detracted from implementation. On these campuses, teachers who were not interested in learning new pedagogy were not encouraged to implement the curriculum, and interested teachers sometimes did not feel supported in their efforts.

Basic components of principal support for implementation

Many teachers and some principals listed several basic components of support that principals provide to help teachers implement standards-based mathematics in their classrooms. Teachers need the materials to implement the curriculum such as books and kits. Although in the first two years of the ACME project the district committed funds to purchase books for all teachers and one kit for every two classrooms, some teachers said that they had difficulty sharing materials because they scheduled lessons at the same time or their rooms were far from their partners' rooms. On certain campuses, administrators bought kits so that every teacher could have his or her own, which many teachers reportedly appreciated. Interviews with teachers suggested that some did not know about the district's role in purchasing the curriculum resources designated for the ACME project.

Teachers perceived additional support when principals found funds for a special copy budget for mathematics lessons. With the elementary curriculum resource *Investigations in Number, Data, and Space*, students do not have texts, and teachers run off copies of student worksheets from the teachers' resources. Particularly when the resources are new and teachers are not yet familiar with what they need to copy and what they can skip, school copy and paper budgets may increase dramatically. Many teachers were pleased if their principal addressed this need.

Another basic component of principal support that many teachers mentioned was time for professional development. The original design of the ACME project provided substitutes for teachers to attend follow-up professional development during school days. In the second year, as a alternative to missing school days, teachers could choose to receive a stipend and attend follow up sessions after school or on Saturdays. Again, not all teachers were aware that the NSF grant pays for substitutes and stipends, not their school principals. Many teachers reported that their principals supported implementation by allowing time for educators to attend ACME professional development. One teacher mentioned that even when the school is short a substitute, her principal made arrangements for teachers to attend follow up sessions.

Many teachers and a few administrators reported these basic components of principal support for implementation. Generally, support in the form of materials and time for professional development reflect a focus on the management of implementation. In the Concerns-Based Adoption Model (CBAM; Hord, Rutherford, Huling-Austin, & Hall, 1989), this focus is a mid-range developmental stage that occurs early on in an innovation and usually after participants face concerns about how the changes will affect them personally. At later stages, teachers become concerned with the impact that the innovation can have on children, how teachers themselves can learn more about the project from their colleagues, and how they can improve upon the innovation itself. Although principal support in the form of these basic components is essential, it is limited. Support that goes beyond materials has the potential for boosting teachers to higher levels of implementation.

Components of strong principal support for implementation

Commitment and expectations

Although strong principal support for implementation has many components, a central component is commitment to the adoption of standards-based mathematics education, which several principals voiced and their teachers perceived. One principal described her role as a "supporter" and a "coach." One of her teachers confirmed this commitment when she said, "Every year they'd [campus administrators] say we'd use the curriculum resources no matter what." In addition, this principal was a pillar of support: In response to teachers' worries about students' passing the TAAS, she said that she told her teachers, "Let me worry about TAAS." When this principal took responsibility for students' academic achievement away from teachers, she alleviated pressure and allowed teachers to try out standards-based teaching practices. This strategy, in combination with others, appeared successful as this campus witnessed increased mathematics scores every year of implementation.

Principals can also express their commitment to the implementation of standards-based mathematics by communicating the expectation that teachers will adopt the ACME curriculum resources. One principal said, "It's not negotiable with me. It's part of the interview with new teachers." One of her teachers described this principal as "very supportive; we're held accountable. We have goal setting conferences...for getting to know *Investigations* better. [The principal] is sold on it." In addition to goal setting conferences, this administrator holds her teachers accountable for implementing by conducting teacher evaluations during mathematics lessons. At another school, the principal shows commitment by monitoring implementation and knowing what it looks likes in classrooms on her campus. She and her teachers reported that she visits classrooms and talks to students to find out what children are doing and understanding during mathematics lessons. This principal further communicates her expectation that teachers on her campus will use standards-based mathematics teaching practices showing interest in their experiences at ACME professional development. By asking questions, she also gains information about the quality of ACME and how it influences her teachers.

Knowledge of standards-based mathematics education

Another key component of strong principal support for implementation of an innovation is knowledge about the benefits of standards-based mathematics and communicating that knowledge to teachers, parents, and the community. One principal stated that administrators need to "read available research." Another principal said that she was "confident" in the curriculum and considered it "grounded in research, and based on substance," although she knows that its success depends on teachers' implementing standards-based curriculum resources and instruction correctly. By increasing their knowledge about inquiry-based mathematics, principals can explain why their school and the district are embarking on this initiative.

Many principals were articulate about the practice of standards-based mathematics. However, results from the previous evaluation of the ACME project cautions that knowing the language of standards-based mathematics does not ensure a deep understanding of what inquiry-based practice should look like and how it affects

children's learning experiences (Batchelder, 1998). A couple of principals acknowledged that they did not know much about the ACME project and standards-based mathematics curriculum and instruction. One assistant principal admitted that he was learning about it at the same time teachers were. Acknowledging the lack of information and making the effort to learn with teachers is a way that principals can solidly support teachers and demonstrate participation in a professional learning community. A few principals reported that they attended conferences and professional development workshops with teachers, and one assistant principal stated that she did so "for teachers." Sharing the learning process with teachers exemplifies strong administrative support for implementation.

One principal who provided strong support also contended that not only did she need to have knowledge about standards-based curriculum and instruction and need to attend conferences to support her teachers, but she also needed to manage public relations. She had to know about the curriculum, be visible, and sell it to parents and the community. This knowledge functions not only to back up teachers, but also to communicate to parents and the community what is different about this teaching practice and how children will benefit from the change.

Systemic vision

In addition to knowledge of standards-based mathematics curriculum and instruction, principals who provided strong support often voiced an understanding of systemic change. They expressed the view that meeting the goals of the ACME project (i.e., all K-8 teachers will provide standards-based mathematics education to all children in AISD) does not merely involve teachers in classrooms and a certain number of professional development days, but it also requires the knowledge and support of district administrators and other members of the community. One principal who was an advocate for strong leadership in central office in support of the ACME project stated:

> If anyone thinks that there is not support at the top, they will think it's only a fly-by-night program. It could collapse and we'd go back to square one. It's important that we educate people at the top, administrators, the board, everyone.
>
> *Source: Principal interview*

This systemic vision of implementation suggests that some administrators understand that in order for districtwide reform in mathematics education to succeed, teachers and campus administrators cannot go it alone: This effort requires support at all levels.

A systemic vision appears to help principals sustain implementation on their campuses and support teachers. One powerful example occurred on one campus when a teacher expressed concern about textbook adoption. She said that she was "worried about other schools dropping it [standards-based curriculum and instruction]." The principal, who had herself internalized the district's goal of implementing standards-based mathematics education districtwide, replied, "I don't see how we can back off from where we [the district & the campus] are going." This example illustrates how this principal was able to support her teachers by invoking the district's support for standards-based mathematics education and thereby assuaging some of their fears. This example

illustrates how strong support for the initiative from central office leaders is linked to supporting teachers' efforts to implement standards-based mathematics curriculum and instruction: Strong leadership at the district level reinforces leadership at the campus level and buttresses support for ACME.

Additional elements of a systemic vision include understanding that teachers need time to adopt an innovation and that the change can positively benefit children. A few principals acknowledged that changing teaching practice is a process that takes time and patience (c.f., Hord, Rutherford, Huling-Austin, & Hall, 1989). Teachers may require two or three years to integrate the new curriculum and instruction into their practice. One principal stated that, for example, TAAS "will work itself out, if the public and the district gives us time to make progress." Whereas one principal was concerned that children would loose time while teachers learn standards-based teaching practice, another principal saw the long-term benefits to children in that the curriculum allows students to make connections to "real life" and their future careers. A systemic vision requires thinking about many factors and how they are interrelated.

Organization of teacher collaboration and leadership

As leaders, managers, and supervisors, campus administrators can formally organize teachers to share materials and ideas about mathematics education and thereby promote implementation. Through formal organization, principals may encourage teachers with experience and competence in standards-based teaching practice to help other teachers learn more and improve their skills. Administrators' pairing teachers who are reluctant or hesitant to try out inquiry-based curriculum resources and practice with teachers who are successfully implementing may also build more interest and competence. On the nine different campuses visited, principals formally organized teachers in a variety of ways, however, with the exception of team meetings, most organized structures occurred at only one or two campuses.

Team meetings. Across the board, administrators organized teachers in grade level teams, though some principals organized vertical teams. Teachers held team meetings at least monthly, but usually weekly. Teachers who were members of vertical and horizontal teams met with both groups. The evaluators observed at least one team meeting per school. In general, little discussion of mathematics content took place at these meetings, although some management of materials and brief discussion of the logistics of mathematics lessons occurred.

Teacher leadership. Several years ago, the district established a plan for every campus to appoint one teacher as curriculum specialist in mathematics as well as in other major subject areas. The purpose of these roles was to disseminate information from the district to campuses through these teachers. Across the district, some campus administrators adopted this plan to varying degrees or transformed the role to suit needs on their campuses. At three sites of the case study, evaluators observed mathematics curriculum specialists who functioned in powerful leadership roles specifically to support standards-based instruction on their campuses. All of these three sites were pilot schools where principals and many teachers demonstrated motivation for standards-based teaching and learning.

At one school, the principal saw herself as a supporter and facilitator of training for teachers yet turned over responsibility for mathematics education to her curriculum specialist. This teacher was particularly knowledgeable of standards-based mathematics education, skilled in the teaching practice, admired by colleagues for these competencies, and served as an advocate for implementation. Evaluators observed his role as advisor to the principal on ideas that support implementation (e.g., teaching children to think mathematically will help them pass TAAS) and as leader of a mathematics curriculum specialist team, which included one teacher per grade level. The observed activities of this team involved disseminating information about mathematics to teachers at each grade level, attending workshops and conferences on mathematics education, and planning a family math night. This teacher was observed collaborating only with one other teacher. As the mathematics curriculum specialist on this campus, it appears that his role is to support the principal with implementation and lead the team, rather than work directly with other teachers.

At another site, the principal appointed a mathematics curriculum specialist who clearly served as liaison between teachers and campus administrators as well as between teachers and district mathematics specialists. When teachers discovered that they needed more paper for photocopying student exercises for *Investigations* lessons, they went to the mathematics curriculum specialist who took the problem to the principal and the two of them decided to make copies unlimited for mathematics. Similarly, the colleagues went to the curriculum specialist for materials; she reported, "I buy what they need, I go to the principal, and I order more stuff." This arrangement appears to run smoothly as the principal was responsive to teachers needs in implementation and allowed the curriculum specialist to order over $1000 in new materials in one school year.

Beyond arranging for more copies and materials, this curriculum specialist also got teachers' questions about the curriculum answered by calling the district mathematics specialist assigned to this pilot school and arranging on-site discussions and modeling of mathematics lessons. This curriculum specialist further supported implementation on her campus by making presentations at faculty meetings on topics such as how *Investigations* relates to the TAAS and the state mathematics standards TEKS (Texas Essential Knowledge and Skills), by providing training in hands-on instruction, and by attending and making reports on district mathematics meetings and national and state mathematics conferences. Thus, this principal met many teacher needs for implementing standards-based mathematics on her campus by designating a teacher leader and liaison.

One principal in the study declared, "We need to depend on teachers to convince others" about the benefits of standards-based mathematics education. The third principal who successfully organized teacher leadership on her campus did just that. She wanted teachers to "catch" the bug from others. She began by appointing two teachers as team leaders who were successful with inquiry-based mathematics, had mathematics expertise, and had their "hearts in it." Each year of implementation, the principal asked one teacher to move from one grade level to the next to be the leader of whichever grade was beginning professional development and trying out the curriculum and instruction. The other teacher leader was responsible for teaching classes and leading colleagues in two different grade levels.

This principal also emphasized dialogue between teachers and asked various ones to move classrooms because "proximity is important for dialogue." She realized that teachers needed time to process what they were learning and that they "learn better from each other" because it is comfortable. Along with organizing teachers, the principal fostered an environment in which it was alright to ask for help and to say that it is "not going so well." As a result of the principal's efforts to promote collaboration, teachers on this campus identified both of the teacher leaders as experts in the curriculum resources. Additionally, nearly every teacher in two grade levels stated that they worked with these teacher leaders (see Figure 1). Thus, this principal thoughtfully and successfully organized the mathematics curriculum specialists as leaders to promote teacher collaboration and capitalize on expertise to guide the professional development of others.

Time for teacher collaboration. The same principal who designated two teacher leaders on her campus decided to offer teachers opportunities to dialogue as they learned to implement standards-based mathematics. She paid for substitutes during the school day so that teachers could have time to process what they were learning about standards-based teaching practice. To hold teachers accountable, she demanded an agenda that outlined teachers' plans for the work session. On two other campuses, the arrangement of time away from teaching responsibilities was less intended for communicating and collaborating on standards-based mathematics instruction than for planning the mathematics and language arts curriculum for the semester, and thus did not support implementation of standards-based mathematics. Whereas at these schools the planning day took place during school, at another the meeting was held before the semester and the principal paid teachers a stipend with school funds.

Another principal developed an innovative plan that had potential to promote teacher collaboration and peer feedback but did not support the implementation of standards-based instruction. She asked expert teachers to use their regular planning time to work with other teachers during mathematics lessons. The experts were paid for an extra planning period after school. This plan *could* be an opportunity for skilled teachers to demonstrate standards-based lessons and to observe the teaching practice of others who are learning how to implement standards-based curriculum resources. With time to give feedback and dialogue about what they observed, the plan could be an effective way to promote peer coaching and standards-based mathematics education, for example. In practice, however, the evaluators understood that the expert teachers on this campus taught the students of other teachers but did *not* discuss the teaching strategies with their colleagues. In addition, the content of these lessons unfortunately was not standards-based mathematics. Campus administrators could adapt this plan to promote high quality implementation of investigative mathematics curriculum resources and instruction.

Other organizational structures. Principals adopted other organizational structures to promote implementation of standards-based mathematics education on their campuses. As previously mentioned, one principal appointed a mathematics specialist team to direct the focus of mathematics curriculum and instruction on the campus. The principal at one school organized a curriculum specialist team that covered all subjects and included one representative per grade level. This team was responsible for developing and modifying a campuswide Unit Design Organizer, which was a manual that outlined what teachers taught at all grade levels in language arts, science, and social

studies as well as in mathematics. At this meeting, teachers were observed bringing concerns from their grade levels about difficulty using the ACME curriculum materials while others discussed how ACME professional development helped with those difficulties. An experienced teacher prepared the agenda and ran the meeting while the principal acted as a participant and provided some leadership support. These other organizational structures demonstrate how principals manage and lead instruction and curriculum that can positively influence implementation on their campuses.

Benefits from an assistant principal with expertise in inquiry-based mathematics

At two schools, assistant principals who had knowledge and experience with teaching standards-based mathematics bolstered campus administrative support for implementation. At one site, the assistant principal had taught for many years and used materials like "Math Their Way" (Baretta-Lorton, 1978). Her enthusiasm for the district's efforts to improve mathematics education with the ACME project was effusive: She said, "Praise the Lord, it's time, past time!" She further described her support by stating, "I believe in it; I understand how it works." She considered her role as "being available to do whatever I need to for teachers and students so it works," which included modeling lessons, observing teachers in classrooms, and recognizing that teachers needed help learning what kinds of questions to ask. One teacher on this campus mentioned this direct support. The principal did not know about her assistant's skills and knowledge. Although some teachers may have improved their teaching skills by working with the assistant principal, her enthusiasm and experience could be better utilized on the campus.

At another campus, the assistant principal was a 4th grade teacher who had herself begun implementation in ACME's first year. She considered her role as "cheerleader," which had fallen on her "shoulders because I'm the one who's done it before." This administrator had recent first-hand experience with learning how to use the curriculum resources and understood the struggles and rewards of the initiative. At her previous campus, teachers stuck with the program because the "bottom line" was that "kids liked it." She had observed that her students did a lot more talking and verbalizing and that the curriculum improved their writing skills, specifically it "made them more sophisticated in writing." She continued, "It does do what the program says it will do; I've seen an increase in the number of kids that like math." She understood certain struggles teachers had such as, "It's hard to figure out classroom management issues." Equipped with this first-hand knowledge, as an assistant principal she was able to articulate the benefits of adopting the curriculum, evaluate teachers' instruction during mathematics lessons, and empathize with traditional teachers who were resistant and struggled with the challenges of standards-based teaching practice.

Reluctant or resistant teachers

Even campuses with strong principal support had a small number of reluctant or resistant teachers (see "Implementation of Standards-Based Mathematics Education, Comparison of levels of implementation across schools"). One resistant teacher, for example, at a campus where administrative support was strong felt that the administrators could not relate to her problems with the curriculum because they were not using it and therefore she went to other teachers for help. Ironically, this teacher taught at a campus

where the assistant principal had years of experience teaching investigative mathematics. Making known the campus level support that is available is clearly important.

At another campus, a whole grade level team had participated in ACME professional development, but each classroom from this team that was observed was not implementing standards-based mathematics education. The principal, who provided her teachers with strong support for implementation and monitored mathematics classrooms, knew about the resistance of this team and focussed on other teachers who were highly involved in implementation. This strong principal support buoyed the efforts of teachers who were interested in learning standards-based mathematics education. Thus, the resistant team did not undermine implementation campuswide.

Components of principal support that detract from implementation

Basic and strong principal support for the implementation of standards-based mathematics indicate campus support for district policies. Principal support that detracts from implementation, however, occurs when campus leaders do not embrace district programs. Whereas some principal support that detracted from implementation provided mixed support for the ACME project, other administrators supported teachers in specific campus programs and goals that did not include ACME professional development and standards-based mathematics education.

Campus goals that conflict with the goals of the ACME project

Some components of principal support for campus teachers detracted from the implementation of the standards-based curriculum and instruction promoted by the ACME project. Campus goals that do not focus on mathematics education can diminish the energy available for school change linked to ACME. At one campus, the principal stated straight out that her campus goals focused on "reading because our kids are far behind." This focus was in contrast with the goals of other schools where mathematics was not necessarily primary but where campus goals were broad enough to include mathematics education. One such broad goal was "all children will be successful in reading, writing, and problem solving." At another campus, the principal was unclear about how mathematics tied in with campus goals and discussed the district's focus on literacy. Principal leadership that does not integrate the district's mathematics initiative into campus goals is in conflict with the goals of ACME project.

A principal that provided strong support for implementation of standards-based mathematics reported that her school intentionally did not apply to be a pilot school that would participate in whole school implementation because:

> We are working on reading and the Academics 2000 grants; we're changing the whole way we do things, which is student-centered.... If we did one more thing, we'd have a revolt. We conferred with team leaders at CAC [Carruth Academic Center] and we agreed not to invest our money.
> *Source: Principal interview*

This principal acknowledged that she could not overwhelm her teachers with so many school programs. Yet, she managed to provide support for grade-by-grade

implementation by encouraging and holding teachers accountable for implementing standards-based mathematics instruction. This principal reported that the campus goals focused generally on student academic improvement, leveling the playing field for children no matter what part of town they come from, and generally preparing them for life. Because these goals were global, the principal did not set up a conflict for all teachers between adopting new literacy and mathematics curricula simultaneously. Thus, the gradual implementation of standards-based mathematics education fit the global goals and accommodated the other programs that the school was also adopting.

Unclear understanding of principal support for implementation

In interviews, evaluators asked principals about their roles in the adoption of investigative mathematics curriculum and instruction. Some principals did not have a clear understanding of their role in supporting teachers with implementation. The fact that evaluators asked the question may have raised the issue for some. One principal stated, "I've never thought about it." With a districtwide project like ACME that has not been initiated by principals themselves, some may perceive that the responsibility for supporting the project rests off campus at the district level. This perception may depend on principals' vision of their role in relation to the district. The balance that principals perceive in their role between implementing district policies and promoting their own campus policies may affect the degree to which they support implementation.

Most likely, the role of principals develops as the ACME project advances and they learn more about it. In the fall, one principal stated that her role was "not much initially," but it evolved to a more powerful stance by the end of the case study. In the spring when the evaluators returned to the campus, the same principal described her role as holding "the expectation that teachers won't abandon it" and "monitoring, supervising, and ensuring it's happening." The second response demonstrates strong commitment and support for implementation. Thus, several months of working with teachers to support the implementation of standards-based mathematics, and perhaps the evaluators' visits and questions, may have influenced some principals' thinking about their role and the actions they take.

Mixed messages about implementation of standards-based mathematics education

Multiple curricula. Another component of principal support that detracts from the implementation of standards-based mathematics curriculum and instruction involves mixed messages that diminish commitment to the ACME project. One set of mixed messages occurred at campuses where the principal either advocated for alternative curriculum resources and teaching methods or emphasized no curriculum resources in particular. At one campus, teachers' comments reflected a variety of understandings about what the campus administrators expected in the mathematics curriculum. A few teachers stated that they were expected to attend ACME workshops and to use the designated curriculum resources. Another teacher on the same campus stated that support for implementing was not present and that "it's encouraged to do TAAS." Several teachers described what appears to be the main message on this campus: The principal "wants us to use a variety of techniques for the [students'] different levels and ways of learning." One teacher said, "We, as a campus, know that it [ACME] has to be

implemented, but as a campus we know its not the only way.... There are other programs that work." She explained further that the principal is very supportive of a supplemental material that focuses on practicing test formats and was bringing the author to campus for professional development. Apparently, a few teachers on this campus perceived some support for implementing standards-based curriculum and instruction, whereas others perceived none but rather an emphasis on preparing children to take the TAAS. Still others understood that this principal valued highly teaching materials and practice that are alternatives to ACME curriculum resources. Because of these mixed messages, few teachers on this campus feel encouraged to adopt the curriculum and instruction of the ACME project; on this campus, the evaluators did not observe a unified, standards-based approach to teaching mathematics.

Additionally, this principal was not familiar with standards-based teaching and learning nor the ACME curriculum resources. At one point in the interview, she confused the ACME resources with the assessment tools of other initiatives in the district, such as the Primary Assessment of Language Arts and Mathematics (PALM). Between the first and second visit of the case study, however, she had taken steps to educate herself and clarify the objectives of the different curriculum resources that she advocated. With a clearer understanding of the resources, she could articulate the usefulness of each one for teaching mathematics. Because these resources are not based on an integrated philosophy, their combination may or may not reinforce children's learning.

At another campus, the administrator said that she places "no more emphasis on *Investigations* than on anything else." Like the previous administrator, this principal stated that her policy was "not using programs, but using what works with kids." At this school, teachers and the administrator emphasized preparing children to pass the TAAS. Some faculty on this campus voiced the unfounded concern that the ACME curriculum resources may work better with children from affluent neighborhoods where parents are highly educated than with students and parents on their campus (see "Perceptions of Parents' Responses to Investigative Mathematics, Teachers' attitudes toward ACME and perceptions of parental responses" and "Views of Children and Investigative Mathematics, School culture and teachers' view of children").

Despite mixed messages about implementing standards-based mathematics, teachers on this campus perceived strong support from the principal and in turn supported her. One teacher stated that the principal provides teachers with "150% support; [the principal] is good; whatever we need she gets, she's awesome." This mutual support on campus illustrates that strong principal support for teachers does not necessarily go hand-in-hand with strong support for the ACME project or any other district program. Thus, a principal's strong support for the teachers on her campus that does not include support for the district's mathematics initiative can detract from implementation of standards-based mathematics.

Some characteristics of these two campuses were similar. The principals at both of these schools acknowledged that they did not know much about standards-based mathematics and that they could learn more about it. Thus, lack of information about the initiative deterred support for implementation. In addition, staff at these two schools expressed a strong campus identity that was separate from the district. Campus identity was evident, for example, in the previous quote in which the teacher identified herself

with "we, as a campus" in contrast to "the district." This identity may have influenced staff to view ACME as the district's project, not as their own. In both cases, principal support did not include strong commitment for implementation of standards-based mathematics.

Mixed support. At another campus, mixed messages took the form of a couple of teachers' reporting strong principal support for implementation and most teachers reporting little support. One particular teacher whom the principal named as a strong implementer of standards-based mathematics reported strong principal support. This teacher stated that in addition to support for photocopying lessons and teachers' attending workshops the principal "constantly encourages us and gives us time to share in faculty meetings." Although the principal said, "There's no time to get into those classrooms," she visited this particular teacher's room during mathematics lessons. This teacher reported that after talking to children in the classroom the principal said, "I really liked that, I was really impressed with what that child told me." Another teacher also felt supported with materials and innovations: "She welcomes any new ideas, so long as you justify why."

Most other teachers on this campus, however, described the opposite experience. Although other teachers acknowledged the administrator's support for ACME professional development and duplicating mathematics lessons, they otherwise reported little or no support for implementation. One teacher described the principal as a "hands-off" administrator whose focus and funds went to literacy while the district paid for mathematics. Other teachers echoed the sentiment that ACME professional development provided support for implementation of standards-based mathematics education and that there was "no part for [administrators] to do." Still other teachers stated that principal support may be available but that they had not asked for any or "haven't seen any extra support." Thus, a small number of teachers at this campus perceived support for implementation that went beyond materials, but most teachers did not.

One question that arises is whether implementation would thrive or flounder with only pockets of strong support. A remarkable characteristic of the campus just discussed was that teachers resounded with positive attitudes toward ACME professional development. In addition, a couple of teachers with little previous experience with standards-based instruction had developed medium to high levels of effective implementation. Perhaps some self-directed teachers would thrive with ACME regardless of the level of support from their campus principal. However, without much administrative support, the concerns of hesitant or reluctant teachers would have to be addressed by district staff or other teachers on campus. The effectiveness of support with low principal involvement should be revisited in the future.

Summary of Principal Support for Implementation

In sum, most teachers received basic support from principals in the form of funds for copying lessons, materials, and time to attend professional development. Strong principal support for the program occurred when administrators communicated commitment to the implementation of standards-based mathematics, gathered information about it, had a systemic vision of implementation, and organized teachers for

collaboration and leadership. A couple of campuses reaped additional benefits from the leadership of assistant principals who had first-hand knowledge and experience teaching standards-based mathematics. Factors that detracted from implementation involved campus goals that did not accommodate the goals of the ACME project, principals who were unclear about their role in implementation, and mixed messages that did not clearly encourage teachers to adopt standards-based practice. In particular, principals that strongly support their teachers at schools that have campus identities that do not integrate some district policies do not manifest strong support for the district mathematics initiative.

Because implementation consistently varied across schools, differences in principal support did not directly determine whether or not teachers effectively used inquiry-based mathematics teaching practices. However, some components of strong principal support (i.e., teacher collaboration and leadership) promoted the buy in of hesitant or resistant teachers. Perhaps strong principal support may contribute to a critical mass that could influence more complete implementation across campuses in the future years of the ACME project. As the longitudinal case study continues, evaluators will assess these possible influences.

Another factor to investigate in the future is how change in administration at these schools influences the future of implementation. In the spring of the 1998-99 school year, one school in the case study lost a principal and another lost an assistant principal both of whom strongly supported implementation of standards-based mathematics curriculum and instruction. When the principal and several teachers left one of the middle schools in the State Systemic Initiative, the Dana Center witnessed total collapse of standards-based mathematics education at the school. Yet, one example does not predict what will happen at individual sites elsewhere. Perhaps, teachers who stay at a campus can continue to carry out the implementation plan designed by a previous administrator or the new administrator's plan may support implementation in new ways. What will happen on these two AISD sites in future is uncertain, but it will be important to observe in order to understand how implementation can work.

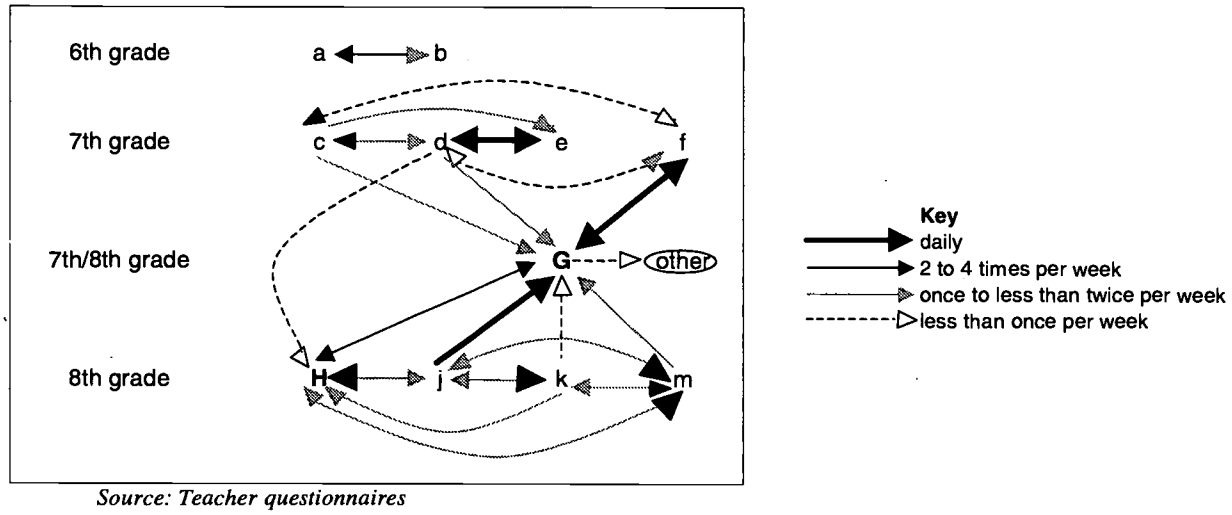
Teacher Collaboration

A key focus of this case study is teacher collaboration because it is a useful tool for educators to explore and learn innovative curriculum and instruction together. In the previous section, strong principal support included principals' efforts to promote teacher collaboration and leadership. This section presents the different kinds of collaboration and contributing factors that were observed at the nine campuses.

In addition to interviews and observations, sociometric maps of who collaborated with whom on mathematics education and how often that were derived from teacher questionnaires informed this discussion. Maps were drawn for all of eight campuses that were visited in the spring, but two are presented here (see Figure 1 on p. 28 and Figure 2 in Appendix D). Letters represent individual teachers, bold capital letters (i.e., **G** and **H**) are identified experts, "other" represents colleagues off campus, and the arrows represent frequency of collaboration in mathematics (see Key). In Figure 1, for example, teacher d reported working with teacher H less than once a week, but teacher H did not name

teacher d as someone she worked with on mathematics education. Instead, teacher H reported that she worked with teacher j one to two times a week, with teacher G two to four times a week, and with teacher m daily. Although five teachers reported that they work with teacher H, only four of those collaborative relationships were perceived as mutual. Note that some teachers did not report with whom they collaborated (see for example, Figure 2 in Appendix D, teacher q at School F).

Figure 1. Teacher Collaboration at School A



Source: Teacher questionnaires

Team meetings

The two major collaborative structures that principals and teachers described were team meetings and shared planning time. Teachers held grade level team meetings at every school in the case study, and at some sites, a few vertical team meetings were held. Grade level team meetings occurred weekly at most campuses, but varied within schools such that a few teams met less frequently (e.g., monthly, occasionally, as needed). The rapport of the meetings varied by campus and team. Some meetings were brief and the teachers disconnected. Other meetings were jovial, but most teachers did not work together beyond the meeting itself. Still other meetings were characterized by respect, leadership, and high levels of involvement. A few campuses had one cohesive grade level team in which teachers worked closely together. In Figure 1, for example, the 8th grade team collaborated on mathematics at least once a week or more and some teachers worked with others daily. In contrast, the 4th grade team of Figure 2 (see Appendix D) was not cohesive, with three teachers reporting that they collaborated on mathematics less than once a week, four teachers reporting collaboration once or twice a week, and two reporting more frequent collaboration.

Discussion of mathematics education

Observations of team meetings at all nine campuses revealed little discussion of mathematics per se but rather a focus on general logistics and planning. These discussions often covered topics like arranging buses for field trips, talking about a video

to show, and deciding whether or not to buy a new refrigerator for the teachers' lounge. Teachers also discussed different subject areas, such as what kind of writing they typically introduced in 4th grade, how often to have students practice writing to prepare for TAAS, and sharing overheads about a science fair. The discussion of mathematics included preparing instructional materials for lessons, for example, finding enough scales for each class to weigh objects and determining how much rice teachers needed for all students. At one observed meeting, a grade level team shared ideas and planned the second family math night of the year. In general, at team meetings the discussion of content and pedagogy of standards-based mathematics was scarce.

An exception to the low levels of mathematics collaboration at meetings occurred with one grade level team at a campus with grade-by-grade implementation. Teachers themselves, with the support of the principal, had launched implementation of standard-based mathematics education before the ACME project targeted their grade level for professional development. The team leader was a seasoned educator with strong leadership skills and training in the inquiry-based mathematics materials of Marilyn Burns. Team members described their first year of trying out the ACME materials as collaborative and exploratory. For example, members taught the same lessons every day, played the games together in advance to understand how they worked, made the materials, and learned about the curriculum. The end result was a team of teachers who were confident about using investigative mathematics curriculum and instruction.

To launch the current school year, this team met at the team leader's home to plan all of their mathematics lessons for the year. The team's current level of collaboration observed was more organizational than exploratory, although two new team members were learning the ropes from the experienced team members. One of the new members reported that the team shared strategies and talked about how to tie the current lesson to previous ones. The team also continued to develop skills in standards-based teaching and learning by observing how other teachers taught the same lessons, which was facilitated by open classrooms. Immediately, teachers could modify their own instruction according to what worked well in a colleague's class.

Meaningful minutes

Universal across teachers and schools was what practitioners call "meaningful minutes." These moments are the opportunities teachers find throughout their workday to share information about curriculum and instruction with their colleagues. Meaningful minutes regarding mathematics education took place during shared planning times and at other times throughout the day as well. Teachers reported that they shared ideas and materials after school, during lunch, at recess, in the cafeteria, at the photocopier, in the teachers' lounge, in the hallway, at ACME professional development, and in passing. A couple of teachers said that they talked on the phone in the evenings or met at each other's homes. In just about any time or place, teachers briefly exchanged information about mathematics education with their colleagues.

In these meaningful minutes, teachers reported that they shared their impressions and experiences in trying out the curriculum resources. Many teachers reported talking about "what worked and what didn't work" in their classrooms. They talked about how

to approach topics, discussed modifications and variations, and assessed what to do when children were having a hard time with the material. Some shared materials that they had made. Some teachers in their second year of implementation reflected with a peer about how certain lessons went last year. Additionally, teachers whose classes were further along guided teachers whose classes were slipping behind schedule on what could be skipped in order to cover essential material.

A benefit of these meaningful minutes is that the messages can carry positive energy that encourages peers to keep learning about inquiry-based curriculum and instruction. One teacher demonstrated this energy when she shared an "ah-ha moment" with her colleagues at a team meeting. She decided to try out a strategy that someone had told her about with her first graders, but she was unsure if they could accomplish the task. Each day, her class would read the date and figure out ways to combine numbers to add up to that number. On the first day that she tried the activity, one of her students in special education was the first to come up with a correct solution. The experience impacted her highly, and she openly shared her joy with colleagues. Thus, one way that meaningful minutes can support teachers in implementing standards-based mathematics education is when teachers become good news bearers and spur on the growth others.

These encounters could also affect teachers' growth with standards-based mathematics in neutral or negative ways. One neutral effect occurred when teachers learned from a peer that certain lessons were difficult to implement with students, but the advice to skip did not fit their own experiences with the same lesson. Meaningful minutes sometimes contained negative information that discouraged teachers from trying out the ACME curriculum resources and teaching strategies. Some teachers reportedly discussed how *Investigations* did not work with the students on their campus. One teacher said, "Schools have different needs by the part of the city they're in: East, West, North, South," and explained that her students did not have the vocabulary to understand the standards-based activities promoted by ACME. Thus, meaningful minutes can also contain beliefs that are not helpful to some or support resistance to implementing standards-based mathematics teaching and learning.

Although many teachers managed to find opportunities for meaningful minutes with their colleagues, others described impediments to talking about mathematics education. Some teachers stated that there was "not much time to talk" or that they were too busy to share materials and ideas about mathematics. At a few campuses, school culture reflected a belief that there was "no time to talk" echoed by a majority of the faculty. Another reason some gave for not talking about mathematics was that their classrooms were distant from the rooms of their grade level colleagues (i.e., the rooms were not in the same wing or one teacher's classroom was in a portable while the other's was in the main building.) Others stated that they did not share because they did not have the same planning time as their grade level team members.

Many administrators stated that shared planning time was an opportunity for teachers to collaborate on mathematics and some teachers stated that the lack thereof prevented collaboration. However, most teachers did not appear to collaborate on curriculum and instruction intensively during these periods. During planning time, teachers were observed primarily preparing for lessons individually and only occasionally exchanging ideas and materials with their colleagues.

Collaboration in pairs

Although most teachers generally did not collaborate deeply about mathematics education at team meetings or during their shared planning times, some teachers worked in pairs to improve their skills and knowledge. Some pairs developed because teachers' classrooms were in close proximity or they shared a two-room portable. Principals influenced the formation of some by establishing "teaching partners" or asking teachers to move classrooms to promote dialogue (see "Components of strong principal support for implementation, Organization of teacher collaboration and leadership"). Other pairs seemed to arise in a helping relationship in which teachers new to inquiry-based practice sought out or received help from others with expertise.

Self-organized pairs

Several teachers described intense partnerships that emerged in their first year of implementation. Teachers who organized these pairs met after school or at one another's homes. Occasionally, these pairs' classrooms were in close proximity. Often these teachers already believed in or were curious about standards-based curriculum and instruction and were willing to work hard to learn how to implement it. Some pairs either began as friends or developed a close relationship through collaboration. The results were positive, evidenced by medium to high levels of implementation in their classrooms. Although these self-organized pairs powerfully launched implementation, the partnerships sometimes broke up when the conditions of collaboration changed. Last year, for example, one teacher reportedly collaborated every Thursday night with a colleague, both of whom were 5th grade teachers targeted to participate in ACME professional development. When the colleague moved to another school across town, the intense collaboration ceased. Another pair ended collaboration when one teacher moved to another section of the same campus.

Mentoring relationships

At a few sites, the evaluators observed teachers with expertise in inquiry-based mathematics education working closely with a colleague who was new to the practice. With mentoring relationships, the novice receives help from the expert and may gain more than the expert does.

One pair involved a 4th grade teacher new to the practice and a 5th grade teacher with expertise, whose classrooms were next door. This multi-age pair had a unique arrangement in that the expert teacher would benefit from helping the other because the 4th grade students would move to the 5th grade teacher's class in the following academic year. The 5th grade teacher benefited because the mentoring relationship ensured that the students he would teach the following year would be familiar with the mathematical concepts prerequisite for 5th grade and enculturated to working in groups and reasoning. During the last nine weeks of school, the expert teacher was able to teach in the 4th grade class for 30 minutes once a week and model lessons because he had a student teacher who was able to cover his classroom. In addition, the novice teacher worked hard to understand the lessons. She said, "You have to study; the books are teacher friendly, but you need to prepare and do it ahead." She also noted that when she did "not get it" her

grade level team met to do lessons and she asked the expert teacher a lot of questions. This pairing appeared to successfully guide the learning of one teacher who might otherwise have struggled with much less support.

At School A of Figure 1, the principal provided strong support for implementation by organizing teacher leaders, fostering an environment conducive to learning, and offering teachers time to collaborate (see "Components of strong principal support for implementation, Organization of teacher collaboration and leadership"). Teacher j of 8th grade mathematics (see p. 28), who was beginning to implement, sought help daily from every teacher on her team (i.e., teachers k, m, and H) and from teacher G; teachers G and H were leaders in mathematics. All members of the 8th grade team reported working with teacher j less often (i.e., one or more times per week) than she reported working with them. The 7th/8th grade teacher leader, however, did not report reciprocating the collaboration. An 8th grade team meeting provided supportive evidence for this helping relationship. Evaluators observed teacher j seeking help with a lesson from teacher leader H, and the two of them scheduled to meet later. This example demonstrates how one teacher utilized the support of teacher leaders as well as every team members as she learned how to implement investigative mathematics.

At School F in Figure 2 (see Appendix D) where implementation was grade-by-grade, teachers bb, cc, and dd made up a team that seemed to rally around the one who was fresh out of college. All three were 4th grade teachers in their first year of implementation, and their classrooms were located at three different places on campus. One of the experienced teachers in the triad stated that when the new teacher said, "my kids struggled with this," the other two gave the new one advice. This experienced teacher also reported that she made assessment tools for ACME curriculum resources and shared them with the other two. Although none of these teachers had expertise in standards-based mathematics teaching and learning, the evaluators observed at least one teacher whose level of implementation was medium/high. The intensity of collaboration in this triad did not appear strong because they all said they were too busy to talk much. However, the work of this team demonstrates seeds of collaboration that could be sowed if some of the constraints were removed such as moving to nearby classrooms and providing extra time for talk and collaboration on mathematics education.

Experts on campus

One clear observation about teacher collaboration that emerged in the case study is that teachers recognized experts in investigative mathematics education but few accessed these resources. Table 3 presents the number of teachers who identified an expert on campus at eight sites when teachers reported who was most knowledgeable and skilled in the curriculum resources. The table shows that at each campus at least one teacher was identified as an expert by more than one colleague and often more than five educators identified the same expert on campus.

Some campuses had more than one expert identified by several colleagues, and all campuses had some experts named by just one colleague. Some teachers identified the 4th or 5th grade level teams on their campus, which had participated in ACME professional development for one or more years, as most knowledgeable and skilled.

About 25% of the teachers who returned questionnaires stated that they did not know an expert on campus. A hint of the teachers' "egalitarian ethic" (see "Overview of the Project") emerged when a few teachers, less than 5%, stated that *nobody* was most knowledgeable and skilled at using the curriculum resources.

Table 3. Frequencies of Teachers Identified as Experts by School

Schools	Number of teachers who identified expert
Pilot	
A	6
C	10
D	14
Grade-by-grade implementation	
E	3
F	9
G	7
H	2
I	7

Source: Teacher questionnaires

It is important to note that most of the teachers identified as experts were members of the teacher cadre, a group of mathematics teachers who were tapped by the district mathematics department to participate in additional ACME professional development. This public declaration of expertise may help colleagues identify who can help with standards-based mathematics education on their campuses.

Underutilized experts. Inspection of the sociometric maps (see Figure 1 on p. 28 and Figure 2 in Appendix D) revealed that experts in standards-based mathematics education on campuses were often underutilized. At five out of eight schools, only one or two teachers reported that they worked with an expert in investigative mathematics education. For example, teachers S and X of Figure 2 (see Appendix D) were identified as experts, but only three colleagues reported working with teacher S and only one reported working with teacher X. At three of eight schools the identified experts were well-utilized such that four to seven teachers reported that they collaborated with experts. For example, in Figure 1, colleagues utilized teachers G and H well for help with implementing standards-based mathematics.

Why teachers underutilized expertise in standards-based mathematics education is uncertain. This hesitance to seek the help that is available implies that valuable campus resources are left fallow.

Teachers' reasons for not working with experts on campus could also be related to their reasons for not collaborating with a colleague with whom they would like to work. About 15% of those who returned questionnaires named someone with whom they were not currently working but would like to. The most common reason for not working together was that both teachers taught different grade levels (n=11). A large number of teachers found that their schedules conflicted (n=10) or that they were too busy to collaborate with those individuals (n=9). The latter reason corroborated the reports of

teachers on a 4th grade team who stated that they did not work with a 5th grade teacher on their campus identified as an expert because she was "too busy." Sometimes people did not collaborate due to their locations (n=9); either they were in a different pod or wing of a school or in a different school all together. Some felt it inappropriate to seek out the individuals that they named because they themselves had not yet been trained in the ACME curriculum resources (n=4). Other reasons listed by 1 or 2 teachers included: being new to a campus, being focused on reading and language this year, being the only bilingual teacher in a grade level, having just met the person they desired to work with, not having enough materials to share, and being unsure about the other's willingness to share ideas or materials. Finally, a few who did not name anyone noted that they didn't know who to go to or even who was using the resources.

Isolated teachers

A few teachers may be isolated from others because no one on the campus who completed questionnaires reported working with them. In Figure 1 (see p. 28), although the 6th grade teachers worked together, their grade level team was isolated from the other grade levels. These teachers were excluded from the rich collaboration on mathematics education that occurred on this campus, including cross-grade collaboration (see "The Role of Principals in Implementation, Components of strong principal support for implementation, Organization of teacher collaboration and leadership" and "Teacher Collaboration, Collaboration in pairs, Mentoring relationships"). However, the reasons that this grade level was isolated may be related to mixed feelings about implementation that one of these teachers openly expressed. Isolation from collaboration could be due to an unwillingness to implement standards-based mathematics or to general isolation from colleagues.

Summary of Teacher Collaboration

In general, evaluators observed pockets of rich collaboration between teachers focused on the mathematics curriculum and instruction promoted by the ACME project. This rich collaboration emerged from pairs of self-motivated teachers who were friends or in close proximity, helping relationships between teachers new to standards-based instruction and experts, and active principal support that fostered a structured, collaborative environment. Although most principals organized teachers' workdays to include weekly team meetings and shared planning times, teachers worked primarily on the logistics of implementation rather than on the content and pedagogy of standards-based mathematics. Meaningful minutes appear to have potential to boost enthusiasm and interest in implementing standards-based mathematics curriculum resources. One source of underutilized resources that could support implementation was experts on campus in standards-based mathematics education.

Teachers' Attitudes Toward ACME Professional Development

Benefits of ACME professional development

In the interviews, teachers were asked how ACME professional development prepared them to use standards-based teaching practices in their classrooms, and on the open-ended items of the questionnaire, some commented on professional development. Although teachers gave a variety of responses, many voiced a consensus about the benefits. Most commonly, teachers appreciated the opportunities to share their experiences in trying out investigative mathematics instruction with other educators. One teacher said that what she "liked most were interactions with teachers and hearing about what they were doing with their students." Another teacher stated that the best part of ACME professional development was meeting other teachers who share their difficulties using the curriculum as well as "the ways they've expanded on things." One teacher reaped direct benefits from sharing because she had a lesson that "bombed last year and got hints and help" from colleagues in professional development; the same lesson went better this year. Another teacher appreciated the support from other teachers who shared her struggles. She said, "It's nice hearing you're not the only person" having difficulties. Although teachers generally agreed about the benefits of sharing with others in professional development, a few voiced frustration at listening to others who did not support the ACME project.

Another benefit of ACME professional development that teachers generally agreed upon was previewing lessons before teaching them. One teacher stated that it was "helpful to actually do the activities before I teach them because it helps me think about the problems, something I don't have time for in my schedule." Another teacher said, "They [ACME staff] are making sure that the next thing I'm gonna do is what they're talking about." In trying out the classroom activities, another teacher learned about how children might think through tasks. She explained, "[The ACME facilitator] tried to spend time going over what kids might do, we had to work through it." Although many teachers reportedly benefited from previewing lessons, a few were not satisfied with the amount of professional development focused on the curriculum resources. For example, one teacher stated, "I wish we had more focus on how to use the books."

A few teachers mentioned additional ways that ACME professional development supported their adoption of standards-based mathematics education. Teachers appreciated planning time, reviews of student work, and the focus on assessment for standards-based mathematics instruction.

The grade-by-grade implementation design of ACME drummed up enthusiasm among teachers not yet targeted to participate. The teacher questionnaires included responses from teachers who had not yet participated in ACME professional development, and constituted nearly half of the comments about professional development. Generally, these teachers looked forward to participating in ACME professional development and stated that they had heard "good things" about the project. Thus, an additional benefit of ACME project is the grade-by-grade implementation design: The positive experiences of participants in ACME professional development generates interest in teachers waiting to participate.

Links between curriculum resources and TAAS

With state and local emphasis on accountability and students' performance on the TAAS, some teachers expressed the relief and reassurance they gained through discussions of the links between the standards-based curriculum resources of ACME and the statewide assessment, but others did not need the information. One teacher said that discussing "TAAS made us feel better." A teacher cadre member reportedly appreciated the facilitators' "showing the bridge to TAAS." On the other hand, other teachers reported that they had heard more about TAAS than they needed. One teacher said that she was "worn out by TAAS stuff; I want to be able to work with the kids and know the main source is covering TAAS." A teacher leader who has already embraced standards-based mathematics education stated that she was tired of constantly hearing about the correlation between the ACME curriculum resources and TAAS.

As discussed previously, some teachers who hesitate to implement standards-based mathematics curriculum resources and instruction have concerns that their students will not be prepared to pass the TAAS (see "Implementation of Standards-Based Mathematics Education, Factors that negatively influence implementation"). In sum, teachers attitudes toward learning about the links vary. Some teachers who are hesitant and unsure about standards-based mathematics need information about the links. Other teachers who are not interested much in innovative teaching practices are probably not interested in the information. Some teachers who already have strong beliefs in inquiry-based mathematics already understand the links and do not need the information.

School culture and attitudes toward ACME professional development

Although teachers expressed a variety of attitudes toward ACME professional development regardless of which campus they were on, at two particular campuses these attitudes characterized school culture. At one site where the campus administrators were not involved much with mathematics instruction, teachers shared positive beliefs about professional development and appeared to grow in sophisticated ways by participating. At the other site where the campus administrators supported multiple approaches to teaching mathematics education rather than emphasizing the ACME curriculum resources, most teachers had negative attitudes toward ACME professional development. They expressed distrust of facilitators who were not currently classroom teachers and skepticism about the effectiveness of the lessons. Thus, to some degree, the beliefs that constitute school culture influence whether teachers seek out and find benefits in ACME professional development.

Summary of teachers' attitudes toward ACME professional development

In sum, the two main benefits of professional development that teachers reported were the opportunities to share their approaches to the ACME curriculum and instructional strategies with colleagues and to preview specific lessons from the resources. Discussions in ACME professional development of the links between the

ACME curriculum resources and TAAS met the needs of some teachers but not others. School culture influenced whether teachers benefited from ACME professional development.

Teachers' and Principals' Perceptions of Parents' Response to Standards-Based Mathematics Education

In interviews, teachers were asked about parents' responses to the investigative mathematics curriculum. Because parents themselves were not surveyed or interviewed, the information in this section is solely based on teachers' perceptions.

Low levels of parental involvement

Across the board, some teachers at all nine campuses stated that generally parental involvement was low. This finding corroborates previous teacher reports of low parental involvement gathered to evaluate the ACME project (cf., Batchelder, 1998). Not only did teachers perceive little parental involvement at school, but they also perceived little parental involvement at home. For example, one teacher said, "We don't get a lot of parental involvement, they're all working, there's not a lot of interaction between the kids and their parents." Although teachers at all campuses described low levels of parental involvement, at some sites the perception permeated school culture. At one campus, for example, most teachers agreed that they received no feedback from parents, and many teachers associated this lack with low parental income and education. At this site, teachers appeared to perceive low parental involvement as an obstacle to implementing standards-based mathematics curriculum resources and to educating these children in general. By the end of the school year, however, one teacher asserted that the campus was tackling parental involvement.

Parents' difficulties with standards-based mathematics education

Some teachers reported that parents were having difficulty adjusting to the inquiry-based mathematics curriculum. Most likely, parents were taught mathematics as computation using algorithms and delving little into complex concepts. One teacher said, "Parents have a hard time with it [standards-based mathematics], they can't help the students, [when the students] can't use the algorithm; one parent couldn't see the strategies that her kid was doing." Teachers reported that parents were frustrated with no textbook to read and felt unable to help their children with homework. One teacher concluded that not knowing how to work mathematics problems in an investigative fashion made some parents "feel bad in front of their children" and that it "takes a lot of power away from parents." In addition, some parents expect their children to drill computation with flash cards and worksheets. Some teachers reported that when they did not send this kind of work home or sent home games instead, some parents spoke up because of concern that the children were not learning mathematics. Other parents complained that the work was too easy for gifted and talented children. At one particular

campus, teachers agreed that parents were generally confused by standards-based mathematics.

In response to parents' struggles with inquiry-based mathematics education, teachers learned to adapt their instructional strategies. Some teachers became "real selective as to what [they] send home." Some teachers spent time in class on investigative activities, but did not assign these activities as homework. Instead, they assigned computation drills or TAAS practice problems for homework. Other teachers made sure children understood how to play the games and could explain them to their parents before sending the work home. A few teachers reported that they explained the philosophy of standards-based mathematics to parents with varying degrees of success; one teachers said that parents were "all real accepting" of it, whereas others got no response at all. Similarly, teachers reported that sending home letters to parents about changes in mathematics education was effective for some but not for others.

Positive parental attitudes toward standards-based mathematics education

Some teachers reported that their students' parents felt positively about the inquiry-based mathematics curriculum of the ACME project. One teacher leader stated, "So far, my parents have been wonderful," and explained that she wrote newsletters, communicated with parents, and included the computation practice that they expected to see. Another teacher stated that the parents of her students were "very supportive of it" and that she had explained the theory to them. The teacher leader of a highly motivated and effective team said, "Our parents love it, we've had no complaints in two years" (see "Teacher Collaboration, Team meetings, Discussion of mathematics education"). Apparently, some parents welcome the standards-based mathematics teaching and learning.

Teachers' attitudes toward standards-based mathematics and perceptions of parental responses

The convergence of evidence from classroom observations, teacher interviews, and observation at family math nights suggests that teachers' experiences with and attitudes toward the ACME curriculum and instruction may influence their perceptions of the responses of parents. One teacher who felt like she had "no choice" but to adopt the curriculum and whose implementation skills were low reported that she had "not heard anything good about the program, most parents don't understand,... they've not bought in." In contrast, a teacher leader on the same campus who was immersed in and strongly supportive of inquiry-based mathematics education found that her students' parents were "wonderful" about it. More evidence for this association emerged at observations of two family math nights. At one campus, a grade level had low turn out of parents, and a teacher openly expressed doubts about the curriculum to them. A cohesive grade level team at the same school reported a large turn out of 50 to 60 parents, and the teachers said that their parents were "very positive" about ACME mathematics education and that they "haven't had any parents question it at all." Changes in teachers' perception of parental responses from the first year of implementation to the second further supports this

relationship. Some teachers stated that discussing the curriculum with parents the first year was the most difficult part. As teachers became more comfortable with inquiry-based teaching practices and more articulate about the pedagogy in the second year, some teachers reported that resistance from parents waned. Thus, the correlation between teachers' and parents' attitudes toward inquiry-based mathematics can be further explored in the follow up of the case study.

Summary of teachers' and principals' perceptions of parents' responses to standards-based mathematics education

At most campuses in the case study, teachers generally perceived low levels of parental involvement in their children's education. Many teachers reported that parents who helped their children with inquiry-based mathematics struggled with the non-traditional format. On the other hand, some teachers perceived positive attitudes toward standards-based mathematics education, although teachers' perceptions may be linked to their own attitudes toward the curriculum.

Teachers' and Principals' Views of Children and Standards-Based Mathematics Education

Relationships with students and the joy of watching them learn are established rewards of teaching (Peterson & Martin, 1990). Researchers have remarked that not only does observing improvements in children's learning influence whether teachers embrace innovations, but it powerfully sways resistors to implement a program (Levin, 1999). Teachers in this study were asked about the changes they observed in children's classroom experiences with investigative mathematics and some teachers volunteered comments about changes on the questionnaire. Teachers' beliefs about the effects of implementing standards-based mathematics on children ranged from benefits to drawbacks. Positive responses tended to reveal a deep appreciation for what children were learning, whereas negative responses revealed teachers' hesitance and mistrust of standards-based mathematics curriculum and instruction.

Benefits for children

The benefits of inquiry-based mathematics start with the observation that more children enjoy mathematics than had when it was focused on rote memorization, computation, and drill. As one principal reported, "What we're seeing are children who are literally happy with math." One teacher said that a child who previously thought he was not good at math said that now he enjoys it. With enjoyment comes success. One teacher who moved up a grade level with her students said that her "kids feel more successful than in the past..., I've seen my slower learners feel more successful." Some teachers see benefits both for children who struggle academically and for those who do not. One teacher wrote that investigative mathematics "touches and enhances students' learning styles." Another teacher stated, "It helps bright children a lot; and the ones who are insecure about math ability, they become validated because there's more than one way

to do things, they get some credit in some steps." A few teachers remarked that children adjusted to investigative learning; the teachers could "see the difference in kids who [had] had *Investigations* the year before."

The question that arises for some skeptics is: Are the children just having fun, or are they learning the basic facts and content of mathematics? Many teachers seemed to think that children gain a deep understanding through investigative mathematics. One teacher said that "having manipulatives and hands-on experiences is better, children get a better understanding of what they're talking about..., and they stay on task with the activities better." Another teacher said, "It makes them [the students] stop and think about the reason why, they make more connections, they say this is like such and such." Other teachers pointed out the links to real-life situations; one teacher said, "They have a different idea about what math is.... They see it as a tool, part of everything we do." Another teacher observed that inquiry-based curriculum helps children develop conceptual understanding. She said, "It's eye opening, [children say], 'I see it, I get it now,' just seeing the light click on." Other teachers noted that inquiry-based instruction with cooperative learning allows children to learn from each other, for example, they learn new ways to approach problems by listening to other children's strategies.

Drawbacks for children

Some teachers reported that children struggled with investigative mathematics and that their students were not at the level of the sample comments in the curriculum resources. One teacher said that the "hardest part was getting them to talk mathematics." Others stated that some students struggled with writing about problem solving, which was an issue for students who excelled in mathematics lessons that had no verbal component. Another teacher stated that the thinking component of inquiry-based mathematics frustrated some children so much that they requested worksheets. Another teacher reported that children wanted to go straight to the answer and that having to justify their responses made mathematics difficult. A few teachers at a school in a middle class neighborhood expressed concern that the expansions for gifted and talented children were not challenging enough, although other teachers at the same school disagreed.

Children's cultural background and standards-based mathematics education

One principal with a Latino cultural background proposed a theory on the basis of her observations of bilingual students on her campus. She suggested that students with Latino cultural backgrounds might not be as well prepared to excel in mathematics education with an investigative format as other students because Latino culture reinforces respect for authority (Maternal & Child Health Bureau, 1998). Latino parents do not encourage their children to take risks or be independent, which may be critical to children's success in inquiry-based learning. Latino children, particularly recent immigrants to the U.S., may search for the "right" answer and may be hesitant to explore or make mistakes. The principal also asserted that by the time these children leave school they change and become more independent. Thus, this observation about cultural diversity holds primarily for children who have not assimilated to mainstream U.S.

culture (i.e., recent immigrants). Educators and administrators should try to understand that some Latino children may not participate actively in cooperative groups and investigations because they have learned that these behaviors are not appropriate in their culture; they may hesitate because of their cultural background, not because they are bilingual or minority students. Teachers should tolerate differences while encouraging bilingual students to explore mathematics.

School culture and teachers' view of children

At a few campuses, low expectations of children's capacities to learn were part of school culture and emerged in teachers' attitudes toward implementing standards-based mathematics. These sites had elements of "toxic cultures" characterized by negative beliefs and values and by roles that staff play to perpetuate negativism (Deal & Peterson, 1998). Teachers at these campuses stated that the ACME curriculum resources may work well with students who live in other regions of the city but not with their students. The vocabulary of the resources, for example, is considered "over the students' heads." One teacher said that this curriculum is harder than others "for students that come from disadvantaged backgrounds, they don't have higher level thinking skills." She also said, "There are kids that are afraid of writing and speaking and they'll sit back and let other kids do it." Another teacher from the same school asserted the extreme position that the school has children who "are not even talked to from when they're born."

These assertions reflect attitudes that the ACME curriculum resources and the abilities of students at this school are mismatched. More generally, the assertions reflect negative beliefs about children's abilities linked to the families and the socioeconomic backgrounds they come from. These negative beliefs can function to ward off innovative instruction and school change; *intervention*, however can still influence change (Deal & Peterson, 1998). Deal & Peterson (1998) found that key ingredients to changing toxic cultures include "bringing toxicity to the surface, giving people a chance to vent, providing a chance to see things could be better, and, finally, offering a more positive path and a large dose of hope" (p. 127). Intervention at schools with toxic cultures could help improve the working environment at those sites as well as influence change in the schools' participation in the ACME project.

Summary of teachers' and principals' views of children and standards-based mathematics education

In sum, teachers and administrators observed that children immersed in investigative mathematics enjoyed learning and made connections that they had not before. Some teachers, on the other hand, reported that children struggled with the writing, thinking, and communicating components of standards-based curriculum and instruction. On a few campuses, these negative views about children's struggles with investigative mathematics were linked to overall negative beliefs about children's ability to achieve academically.

SUMMARY AND RECOMMENDATIONS

Implementation of Standards-Based Mathematics Education

The case study revealed the following conclusions about the implementation of standards-based mathematics education in the ACME project's second year:

- The mathematics lessons of teachers at all nine schools manifested a range in standards-based mathematics curriculum and instruction, regardless of whether the schools were far along or struggling. Differences in implementation levels emerged by individual teachers, not by schools.
- In general, the study did not reveal differences between schools with whole school and grade-by-grade implementation; teachers' skills in standards-based mathematics were varied regardless of implementation design. However, campuses with whole school implementation received on-site support from ACME staff (e.g., modeling and discussing lessons) and appeared to have stronger mechanisms for supporting reluctant or hesitant teachers in implementing than did schools with grade-by-grade implementation.
- The characteristics of teachers who implemented effectively included: (a) beliefs in the philosophy of standards-based mathematics education; (b) excitement about the curriculum, willingness to learn, or strong skills in teaching mathematics; (c) confidence in the academic capacities of children; (d) classroom management that supported children's active engagement; and (e) efforts to learn how to implement the curriculum resources, despite fears or hesitancy.
- The more teachers reported that they liked using *Investigations* and *CMP* and the easier they found using the curriculum resources, the greater the number of lessons per week they reported teaching from the resources. There was a tendency for teachers new to the profession to be more willing to use *Investigations* and *CMP* than those with many years of experience.
- Alternative curriculum resources to *Investigations* and *CMP* included conventional textbooks, standards-based supplemental materials, and test format practice.
- Two factors negatively influenced whether teachers' implemented standards-based curriculum and instruction: On all campuses, some teachers expressed concerns about students' not passing the Texas Assessment of Academic Skills (TAAS) and, on a few campuses, compounded crises on campus detracted from implementation.

Recommendations

- Continue to provide varieties of professional development that address the range of skills, knowledge, and interest levels teachers have in standards-based curriculum and instruction. Include some information about TAAS successes and alignments to address the concerns of some teachers. Cater professional development to individual teachers, not whole schools.
- To address the concerns and needs of hesitant or reluctant teachers, continue to educate principals about the characteristics of strong principal support for the

implementation (e.g., communicating the expectation that teachers will implement, acquiring knowledge of standards-based mathematics education, and organizing teacher collaboration).

- Continue to encourage teachers to try out standards-based mathematics materials and supplements because their feelings about the materials are related to use. Continue to encourage open dialogue in professional development and on campuses so that the enthusiasm of some teachers might spread to others; likewise, the concerns and fears of hesitant teachers need to be aired and addressed.
- Provide every campus with a library set of all curriculum resources so that teachers can access resources of lower grade levels to simplify lessons.
- Support the use of alternative curriculum materials that are aligned with state and national standards for mathematics education.
- Realize that despite compounded crises on campuses, some teachers may manage to adopt standards-based mathematics curriculum resources and instruction with district support in the form of ACME professional development.

The Role of Principals in Implementation

Interviews with principals and teachers revealed the following information about how administrators were supporting the implementation of standards-based mathematics:

- Basic principal support for implementation included supplying kits to every teacher, special copying budgets for student sheets, and time for professional development. This level of support focused on the management of implementation, which, according to the Concerns-Based Adoption Model (CBAM, Hord et al., 1989), occurs early on in an innovation before concerns about its impact on children, how teachers can collaborate, and how to improve the project itself. Note that in the 1999-2000 school year, the board of trustees will fund copies of student sheets and kits for every K-8 mathematics teachers.
- Strong principal support for implementation included:
  a. principal commitment to ACME, communication of the expectation that all teachers will implement the project, and monitoring teachers' standards-based mathematics instruction;
  b. gathering information about standards-based mathematics education and selling it to parents, teachers, and the community;
  c. having a systemic vision of implementation and the need for district support; and
  d. organizing and promoting strong teacher leadership, which occurred more often at schools with whole school than grade-by-grade implementation, and providing time for teacher collaboration and peer coaching outside of weekly team meetings.

  However, even where strong principal support, faculty may include teachers who are reluctant or resistant to implementing (see "Implementation of Standards-Based Mathematics Education").
- Assistant principals with knowledge and expertise in standards-based mathematics education bolstered principal support for implementation on campus.

- Principal support that detracted from the implementation included:
  a. campus goals that conflicted with the goals of the AISD mathematics improvement plan or were not broad enough to include standards-based mathematics curriculum and instruction;
  b. unclear understanding of how principals could support teachers in the implementation of standards-based mathematics, although thoughts about principals' roles developed over the course of the study;
  c. mixed messages about implementation (e.g., advocating for alternative curricula or none at all), which was linked to a campus identity of separateness from the district; and
  d. support for the implementation of a few teachers on campus but not for all.

Recommendations

- Continue to educate principals about the components of strong support for the implementation of standards-based mathematics, and encourage them to go beyond basic support as the management of implementation.
- Educate central office administrators, school board trustees, and the community about the ACME project to foster clear messages districtwide and support for the implementation of standards-based mathematics education.
- Address principal support that detracts from the implementation of standards-based mathematics and other AISD programs as a district initiative campus-by-campus.

Teacher Collaboration

Observations of teacher collaboration across campuses revealed the following results:

- Although principals and teachers cited team meetings and shared planning times as opportunities for teachers to share materials and ideas about mathematics education, discussion of content and pedagogy on these occasions was rare.
- Teachers found "meaningful minutes" to share their experiences trying out standards-based curriculum resources. Sometimes the messages promoted implementation with good news and on occasion the information was negative or neutral.
- A few teachers collaborated deeply on standards-based mathematics education in pairs that were self-organized or mentoring relationships between experts and novices.
- Although several teachers on most campuses identified an expert in standards-based mathematics education, typically few teachers collaborated with that person to hone their skills and knowledge. Common reasons for not collaborating were structural, such as teaching different grade levels, having conflicting schedules, being too busy, and not working near one another.

Recommendations

- Educate principals about the paucity of high quality teacher collaboration observed in the district. Encourage principals to establish campus initiatives that promote intensive teacher collaboration. The following are suggested forms of teachers collaboration:
  a. Promote monthy or bi-monthly opportunities for teachers to collaborate on the content and pedagogy of standards-based mathematics education in their first two years of implementation. To ensure meaningful collaboration, require teachers to set goals for deep exploration of materials and to report back to faculty discoveries made. Include book studies and analysis of student work and thinking, for example.
  b. Identify teachers who are experts on campus in standards-based mathematics education and enlist them in leadership roles and provide them with release time to mentor teachers new to standards-based mathematics curriculum resources and instruction.
  c. Organize pairs or networks of teachers across campus to foster peer coaching and mentoring relationships.
  d. To provide release time, for example, pay for substitutes for half-days, pay for extra planning times, make use of student teachers, or other methods. Funding sources could include NSF, Title, or Excel funds among others.

Teachers' Attitudes Toward ACME Professional Development

The case study revealed the following teacher attitudes toward professional development:

- The most common benefit of ACME professional development was sharing their experiences with colleagues, which included innovations, extensions, and struggles with trying out the materials. Teachers also appreciated previewing lessons, reviewing student work, discussing assessment, and having planning time.
- Information about the links between TAAS and the curriculum resources in professional development allayed the fears of some teachers but was not needed by others.
- Teachers' attitudes toward ACME professional development were related to the positivity or negativity of their school cultures.

Recommendations

- Continue to provide high quality professional development in standards-based mathematics education that incorporates collaboration and the variety of interests and needs teachers express.

Teachers' and Principals' Perceptions of Parents' Response to Standards-Based Mathematics Education

Teachers and principals reported the following information about parents' response to ACME:

- Teachers generally reported that parental involvement was low.
- Teachers observed that parents struggled with standards-based mathematics, which demanded approaches to problem-solving that were unfamiliar and did not rely on traditional methods such as drill and computation practice; standards-based mathematics education confused and "took power away from parents."
- Teachers' attitudes toward the curriculum and their reports of parents' responses to standards-based mathematics appeared linked; teachers with positive attitudes seemed to report support from parents whereas teachers uncomfortable with the curriculum seemed to report negative parental attitudes.

Recommendations

- Educate parents about standards-based mathematics and improve parental involvement at the campus level; for example, send home classroom and/or campus newsletters with tips for implementation at each grade level, provide parents curriculum guides or primers on children's mathematics classroom activities, and expand family math nights to all campuses (e.g., the Dana Center's kit for standards-based parent education events).
- Enlist support for standards-based mathematics education from Campus Advisory Councils (CAC), parent leaders, and Parent Teacher Associations (PTA).

Teachers' and Principals' Views of Children and Standards-Based Mathematics Education

Interviews with teachers and principals revealed the following changes in children's classroom experiences with standards-based mathematics:

- More children felt successful in and enjoyed mathematics than before. They also acquired a deep understanding of the mathematics content.
- Some teachers perceived drawbacks to standards-based mathematics as they observed children struggling to communicate and write about mathematics.
- At a few sites, school culture reflected low expectations for students' academic achievement and a hopelessness about implementing standards-based mathematics education.

Recommendations

- Provide opportunities for teachers to observe students in classrooms of others skilled in standards-based mathematics instruction where children are excited about learning mathematics.
- In ACME professional development and at the campus level, encourage teachers to share their experiences with children's success in standards-based mathematics education.

- Continue to provide experiences in professional development that promote teachers' confidence in helping children to communicate and write about mathematics.
- Develop a districtwide strategy to increase expectations for all students' mathematics performance.

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Appendix A
Principal Interview

Principal_____
Campus_____
Interviewer_____
Date_____

1. How do you feel your school is progressing with the implementation of the ACME project?

   Probes: What highpoints/successes have you had so far?
   What constraints/barriers have you've encountered? How are you addressing them?

2. Could you tell me about a teacher or classroom where you think this project is taking hold?

3. Could you tell me about a teacher or classroom where it does not seem to be taking hold?

   If GRADE-BY-GRADE implementation,
   Are the teacher of the grade levels that have not yet participated in professional development trying out the investigative curriculum and instruction in their classrooms?
   Probe: Could you tell me more about that?

4. Are teachers in your school sharing materials and ideas about teaching mathematics?

   Are these arrangements formal or informal?
   Probe: When are they able to get together?
   Probe: Have you as principal made any arrangements in scheduling to allow this to happen?
   Probe: How is it working?

5. What is your role in the adoption of investigative mathematics curriculum and instruction?

   How was the administrators' meeting about the ACME project useful to you?

6. How do you feel about the district's project to improve mathematics education?

7. How does the project fit with your campus goals?

   Probe: Does the project affect/influence those goals?

Appendix B
Teacher Interview

Teacher_____
Campus_____
Interviewer_____
Date_____

1. How long have you been using investigative mathematics in your classroom?

   Could you tell me about that?

2. What do you like about these mathematics curriculum and teaching practices?

   What are some problems you've had using them?

3. How has professional development prepared you to use these teaching practices in your classroom?

   Probe: Could you give examples?

4. How is the teaching practice of the ACME project different from what you were doing before?

5. Do you think that investigative mathematics changes children's experiences in your classroom?

   Probe: Could you tell me more about that?

6. How are the parents responding to the mathematics curriculum?

7. Do you share materials or ideas about mathematics education with your colleagues?

   With whom?

   When?

   How?

8. What kind of support are you getting from your school administrators?

Appendix C

Form _____

ACME Questionnaire for Campuses

Please circle or write your response to the following questions.

1. **What grade level(s) are you currently teaching?**

   K 1 2 3 4 5 6 7 8

2. **How many years have you taught prior to this school year?**

   _____ years

3. **How many years have you been using *Investigations* or *CMP* in your classroom?**

   1 2 3 4 5 or more Have not used it

4. **Indicate the number & type of *ACME* training sessions in which you have participated.**

   Summer Institutes:
   0 1 2

   Follow-Up Sessions during school year:
   0 1 2 3 4 5 6 7 or more

5. **How many *Investigations* or *CMP* lessons per week do you typically teach?**

   0 1 2 3 4 5

6. **When you do not use the *Investigations* or *CMP* resources in your mathematics lessons, what other curriculum resources do you typically use?**_____

   _____

7. **If you are currently using *Investigations* or *CMP*, how much do you like using the resources?**

   1 2 3 4 5 Not using it
   Not at all **Very much**

8. **If you are currently using *Investigations* or *CMP*, how easy are the curriculum resources to use?**

   1 2 3 4 5 Not using it
   Difficult **Easy**

9. **Please write the names of the colleagues with whom you share materials or ideas about mathematics education. Please also indicate how many times a week you work with each colleague and other subjects that you work on together.**

People	Frequency	Other subjects you work on together
1)_____	_____	_____
2)_____	_____	_____
3)_____	_____	_____
4)_____	_____	_____
5)_____	_____	_____

10. **Who do you think is the most knowledgeable & skilled at using *Investigations* or *CMP* in your school?**

_____

11. **Is there someone you'd like to work with on mathematics education but currently are not? YES / NO**

If so, who is that person?_____

Explain why you're not currently working with that person. _____

_____

_____

12. **Please include any comments, concerns, or experiences you wish to share with us about using *Investigations* or *CMP*.**

_____

_____

_____

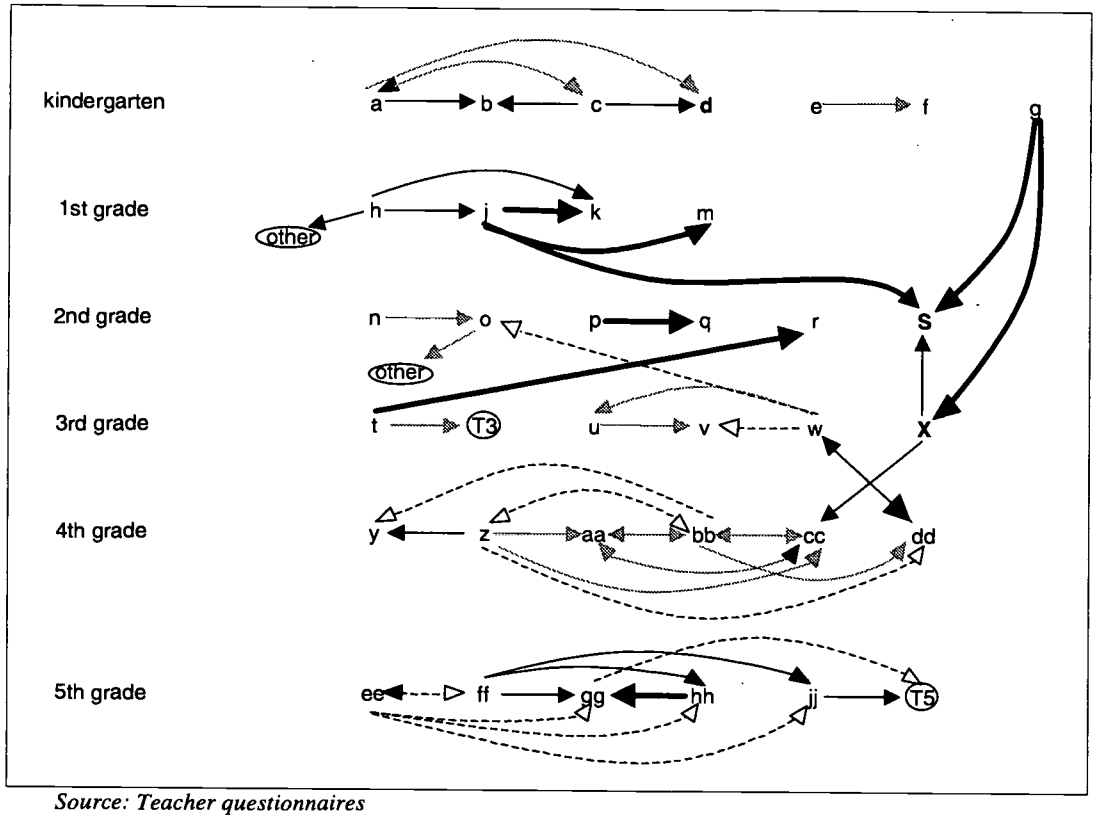
_____

_____

_____

Appendix D

Figure 2. Teacher Collaboration at School F



Source: Teacher questionnaires

Figure 2 is a sociometric map of School F representing which teachers collaborated with whom on mathematics education and how often. The information was gathered from teachers' responses to question #9 of the teacher questionnaire (see Appendix C). Each row is a grade level. The letters on the rows represent individual teachers, bold capital letters (i.e., **S** and **X**) are identified experts, "other" represents colleagues off campus, and "T5" stands for the 5th grade team. The arrows represent the frequency of collaboration in mathematics between pairs of teachers (see Key above).

Figure 2 illustrates the following main findings on teacher collaboration:

- *Underutilized experts.* Teachers at School F identified teachers S and X as experts in standards-based mathematics curriculum and instruction. One teacher on campus reported working with teacher X and three teachers reported working with teacher S, one of whom was another expert. Thus, resources on campus are not accessed.
- *Discussion of mathematics education.* About half of the collaboration on mathematics among 4th and 5th grade level teachers targeted for implementation is infrequent and occurs less than once per week. If this collaboration takes place at team meetings, it is probably not comprehensive exploration of content and pedagogy.
- *Mentoring relationships.* Teachers bb, cc, and dd demonstrate collaboration between two experienced teachers who had participated in ACME professional development and a teacher who was new to teaching and a novice in standards-based mathematics.

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